SEP 2 0 1933

INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 6 SEPTEMBER, 1933 NUMBER 9

SOME OF THE 360 TWO-PEN PRESSURE RECORDERS AT GIBSON REFRIGERATOR CO., GREENVILLE, MICH. (Courtesy C. J. Taglabue Mfg. Co.)

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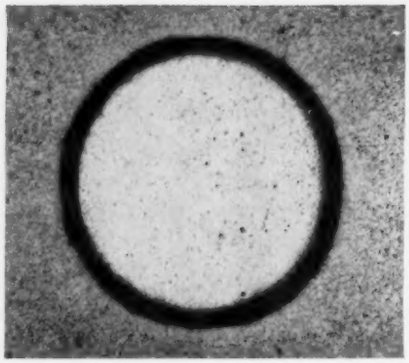

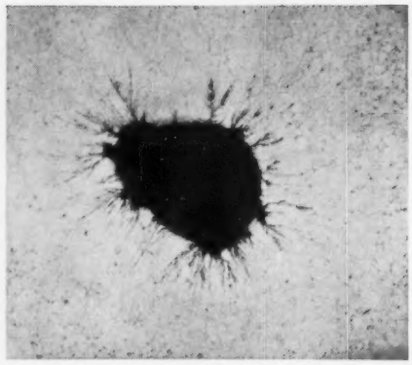

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That is *why* Taylor Accuratus Tubing gives permanent compensation for fluctuating temperatures between bulb and recorder

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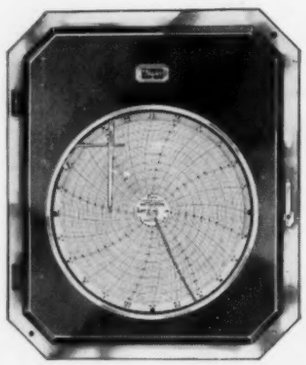

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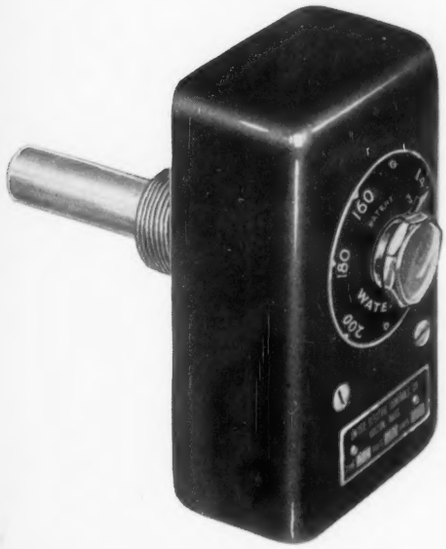

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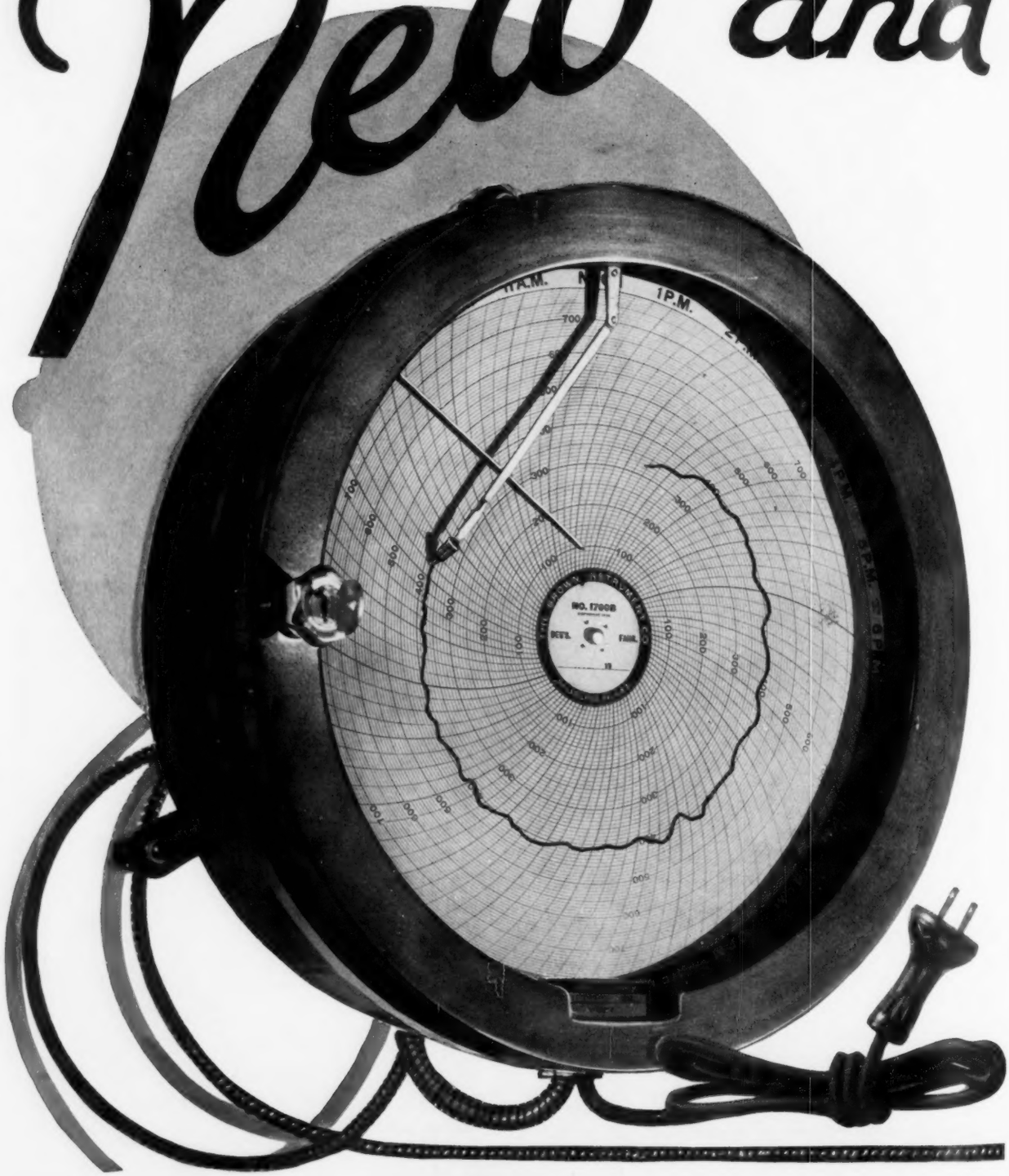

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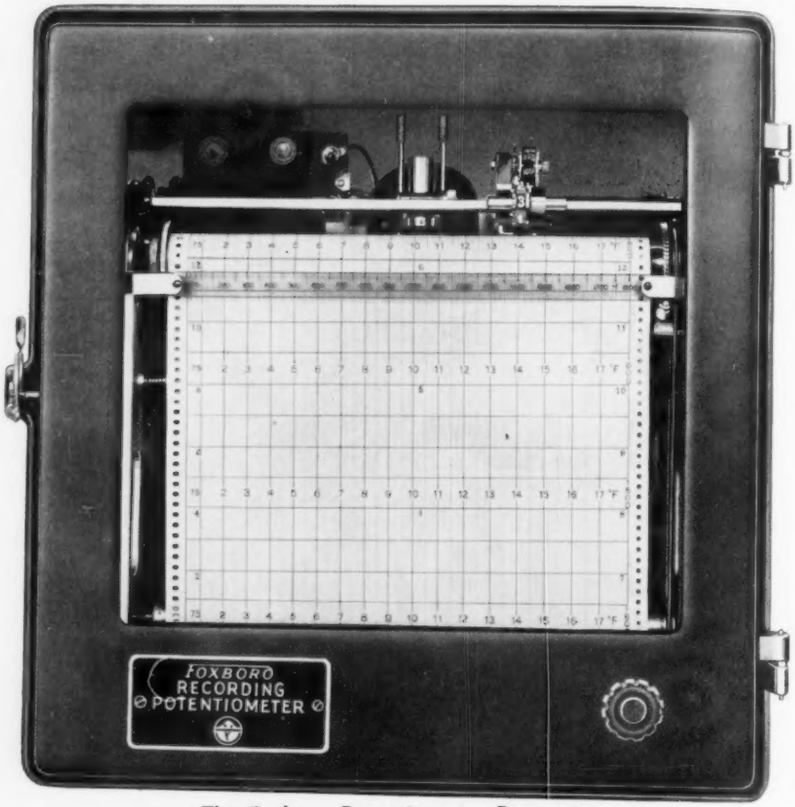

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EDITORIAL COMMENT

In This Issue

♦ Three months ago the mail brought a manufacturer's announcement of what looked like "just another" pressure regulator, but excitement gripped us when we discovered that it had an almost unbelievably "flat" regulation characteristic. Smelling a back-of-the-news story that *Instruments* readers would enjoy, we went a-hunting for the inventor and finally ran him down in his den behind formidable No Admittance signs in the Airco research building in Jersey City. Preconceived notions—those devils that blind many solution-seeking engineers—never had a chance to hamper **George M. Deming,** for when he began his five-year work on the problem of **High-pressure Gas Regulation** he threw overboard existing designs which were supposed to be "perfected." He started from scratch as if no gas regulator had ever been developed by anyone else, but he never failed to profit by the experience of others. On the contrary, whenever he found himself on a previously-traveled road leading to mediocrity, he resolutely left it to explore untrodden paths in search of excellence.

♦ This month's instalment of our book on **Flow Measurement and Control** deals with precision measurement of gas by means of bellows meters.

♦ Seven columns of **Book Reviews** bring to your attention critical estimates of recent works on live topics.

♦ The **Instruments Index** re-appears for your convenience on pages A10 and A11.

◈ ◈ ◈

The Front Cover

♦ An outstanding example of the Instrumentation of an inspection department is shown this month. 360 two-pen pressure recorders (Tagliabue) are used for testing Gibson refrigerators before shipment. The serial number of each machine is written on the simultaneous high-pressure and low-pressure chart, which thus becomes a permanent record of the characteristics of the expansion valve, etc. Considerable reduction in the nation's "servicing" overhead is only one of the blessings that will come when more industries adopt *autographic records of performance characteristics!*

"We Do Our Part"

TO be a good fellow, to follow the crowd, to "play ball" with those who are able to confer favors, and to give no heed to the still small voice within—that is the well-known "easier way."

We do not choose to follow it. We have hewn to the line in the past, and we shall do so in the future as the occasion arises—no matter how many chips fly or where they land.

At the end of our November 1932 editorial on "True and False Repair Economy" appeared the following paragraph:

> Finally, beware of "bootleg charts." A plant using thousands of dollars' worth of recorders on processes involving millions yearly naturally expects the utmost accuracy. To jeopardize it by taking a chance on cheaper charts made from photoengravings instead of wax plates . . . that is the falsest economy! Besides, part of the cost of an original chart covers the original research whereby the scale was established, so that it "isn't cricket" to buy pirated copies.

Since then, printers have come to us protesting that this is unjust, unfair, unreasonable and (severest accusation) not to the best advantage of instrument-using plants. They have offered us money to advertise their charts in *Instruments.*

We refuse to retract any statement or qualification which we made in that concluding paragraph, which was written neither in haste nor in ignorance but from years of experience. In the discussions we have had since November, every additional fact which we have learned has confirmed us in our stand.

We repeat that an industrial plant using a number of recorders *does* take chances with the value of its records if it stops buying the recorder manufacturers' charts and begins to buy cheap charts printed from photoengravings. It may be possible to produce exact counterfeits by employing modern processes of photoengraving and special presses which perforate the guide holes in perfect register, but "bootleg charts" may not be such perfect duplicates. The buyer does not know. He takes a chance.

We repeat also that part of the cost of an original chart covers the original research whereby the scale was established, so that it "isn't cricket" to buy pirated copies, and now that NIRA is in effect we amplify this statement by declaring that all users of recording instruments may "do their part" in the great program of industrial recovery by cheerfully supporting the instrument makers' continued research. If instrument makers are compelled to cut down on their research and development work, the remarkable progress made during recent years despite the depression will eventually have to be diminished, and this would be distinctly to the disadvantage of instrument users.

We have refused the money of the would-be advertisers of "substitute" charts.

We now hear that suits were brought by two instrument companies, which resulted in consent decrees, and in an agreement on the part of one chart printer not in the instrument business, in effect as follows:

> The graduations of copyrighted charts are not to be reproduced. Where the chart is not copyrighted, the graduations may be reproduced but the printer must use a different chart number from that used by the instrument manufacturer and may not use any dress or marks resembling the dress or distinctive marks used by the instrument manufacturers to identify their charts, except color. Further, the printer has agreed to adopt a different style of chart border and center, and to place its name in the center so as clearly to distinguish its charts from the originals.

This is a step in the right direction because it lays down a legal definition of "pirated" or "bootleg" charts.

We are confident that the readers of *Instruments* do not countenance unfair business methods, and that they will zealously do their share in helping to put an end to "pirated" or "bootleg" charts (as defined by the agreement) by showing this editorial to purchasing agents, and in other ways.

M. F. Behar

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Managing Editor

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New Principles in Precision Regulators for High Pressure Gases

By GEORGE M. DEMING*

PART ONE—PRACTICAL REQUIREMENTS

Problems Involved

1. Commercial gases, such as oxygen, hydrogen, nitrogen, and carbon dioxide are usually supplied in steel cylinders at pressures as high as 2000 lbs./in.^{2}, and in some instances even higher. But for industrial applications, as well as for most laboratory work, the delivery pressure frequently is a few inches of water, and as a rule does not exceed 10 or 20 lbs./in.^{2} Not only must the high cylinder pressure be reduced, but generally the delivery pressure must be quite constant. A common characteristic of most pressure regulators of this class is that the delivery pressure is affected by the degradation of cylinder pressure which accompanies the progressive drainage of the cylinder. But this is not the sole regulation problem involved, for the low temperature caused by expanding gas frequently introduces serious regulation disturbances—particularly when the gas contains an appreciable amount of water vapor or other readily condensable constituent.

2. In addition to strictly regulation problems the designer must give considerable attention to maintenance problems. In particular, leakage of high-pressure gas from the cylinder through the regulator valve may become a troublesome factor.

3. Another important consideration is the matter of safety features, for without these there is the possibility of suddenly filling the low-pressure chamber of the regulator with gas at full cylinder pressure.

4. Finally, there are many applications where it is desirable to meter the gas. The regulator is then equipped with some sort of metering device, but to make the complete regulator assembly both compact and relatively inexpensive, it usually has been found necessary to sacrifice accuracy and ruggedness in the design of the meter. Thus it is not uncommon to find such meters in error by 10 or 20%.

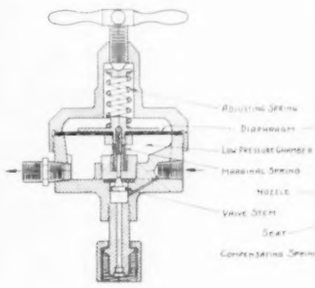


Fig. 1

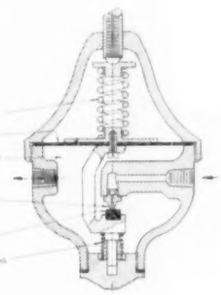


Fig. 2

Fundamental Considerations

Before considering the solution of these four problems, brief references will be made to the theory of operation of pressure regulators, including the terminology which has been found useful in treating this subject.

In general, a pressure regulator contains some kind of a regulating valve which controls the amount of gas discharged into the regulator. In addition, it contains some pressure-responsive element that determines the degree of opening of the control valve. The regulating valve usually consists of a discharge port and some movable element which coöperates with the discharge port so as to control the rate at which gas will be discharged from it. For most regulators of the class being described the member containing the discharge port is termed the "nozzle" and the movable element, which usually is of a relatively soft and resilient material, is termed the regulator "seat." See Figs. 1 and 2. The displacement of the valve seat from the nozzle is controlled by the pressure-responsive element, which usually consists of some movable diaphragm backed by a spring whose stress is adjustable through wide limits by means of an adjusting screw. Any tendency toward an increase of delivery pressure results in an increased gas thrust beneath the diaphragm, and consequently in an outward movement of the diaphragm which in turn causes a closer approach of the seat to the nozzle, so that the tendency toward an increased delivery pressure is thereby resisted. Conversely, any tendency of the delivery pressure to diminish results in a greater seat displacement and consequently in an increased discharge of gas from the regulator nozzle.

Such is the mode of operation of a pressure regulator reduced to its simplest terms, but somewhat more complicated considerations are involved in practice. One of the most important of these is the effect of change in cylinder or inlet pressure. An ideal regulator would be one which maintains a low delivery pressure notwithstanding a deterioration of cylinder pressure from an initial value of more than 2000 lbs./in.^{2} to an end value of less than 20 lbs./in.^{2}, that is, a loss of more than 99% of the initial inlet pressure. But a change of more than 2000 lbs. of inlet pressure means a loss of high-pressure gas reaction against the regulator seat which, for the average regulator, is on the order of 10 to 30 lbs. of force. The equilibrium of forces controlling the position of the valve seat is thereby disturbed, with the result that the delivery pressure of the regulator is adversely affected.

The precise nature of the resulting disturbance of delivery pressure will depend upon whether the regulator is of the "direct" or of the "inverse" type. A direct pressure regulator may be defined as one in which the thrust of the high-pressure gas is in such a direction as to tend to force the seat away from the nozzle. See Fig. 2. It will also be found convenient to apply the term "inverse regulator" to those regulators in which the thrust of the high-pressure gas is in such a direction as to tend to close the seat against the nozzle. See Fig. 1. Obviously, a diminished gas thrust against the seat of a direct pressure regulator as a result of falling inlet pressure must cause the seat to move toward the nozzle and reduce the rate at which gas is being delivered into the low-pressure cavity. Hence the delivery pressure of a direct pressure type of regulator tends to fall with diminishing cylinder pressure. For precisely opposite reasons the delivery pressure of an inverse pressure type of regulator tends to rise with diminishing cylinder pressures.

But at low cylinder pressures, and particularly for heavy outflows, the delivery pressure of both types of regulators will suffer a progressively increasing rate of deterioration until finally the delivery pressure will fall off more or less suddenly. Thereafter it is falling so rapidly that the regulator may no longer be said to be functioning as a pressure-regulating device. See Fig. 3. The low cylinder-pressure range of progressively increasing deterioration of delivery pressure will hereafter be referred to as the region of low-pressure regulation. This is known to be a region in which the movement of the seat away from the nozzle (to accommodate the increasing specific volume of the gas discharging from the nozzle) becomes relatively a more important factor than the change of the thrust of the high-pressure gas against the seat. The more or less indefinite point at which the regulator ceases to function adequately as a pressure regulator will hereinafter be designated as the "regulation end-point."

Where a single regulator will not afford sufficiently precise pressure regulation, two regulators are often used in series inasmuch as the delivery pressure of the second will then be affected only by the relatively small variation of the pressure delivered by the first instead of by the extremely wide variation of inlet pressure characteristic of regulators working directly off of the compressed gas cylinder. When the two regulators are embodied as a single unit, the resulting assembly is known as a two-stage reduction regulator.

Disturbing Influences

In practice, the fundamental regulation characteristics of a regulator, such as just described, are often considerably modified by disturbing influences, among the most important of which are precooling and friction. As previously mentioned, regulation disturbances as a result of precooling phenomena are characteristic of wet gases. Inasmuch as many of the commercial gases are saturated with water vapor, such disturbances are of rather common occurrence. If the atmospheric tempera-

*Apparatus Research and Development Department, Air Reduction Sales Co.

ture be less than 40 or 50° F., the precooling may be sufficient to freeze particles of water which have been precipitated on the cold walls of the approach passages to the nozzle. Such freezing, even when the amount of water vapor originally contained in the gas is rather small, may obstruct the nozzle discharge so effectively that the delivery pressure will abruptly fall. With falling delivery pressure the regulator diaphragm will move inwardly and the seat displacement will accordingly increase, soon becoming great enough to permit the small ice crystals to be violently discharged from the nozzle, whereupon there follows a suddenly increased rate of discharge of the gas from the nozzle, which is only stopped when the pressure reaches an excessive value. The result is a repeated and usually a severe disturbance of the delivery pressure.

But the seriousness of precooling phenomena is not confined to those cases in which the atmospheric temperature is as low as 40 or 50° F. Even at the higher summer temperatures the precooling may be great enough where heavy flows are involved to precipitate moisture in the approach passages to the regulator nozzle. When it is considered that in the average regulator the normal seat displacement at full cylinder pressure is usually a matter of only a few hundred thousandths of an inch, it will be appreciated how effectually a single drop of water will block the discharge from the nozzle. Consequently, even in summer, precooling may give rise to severe disturbances in the delivery pressure.

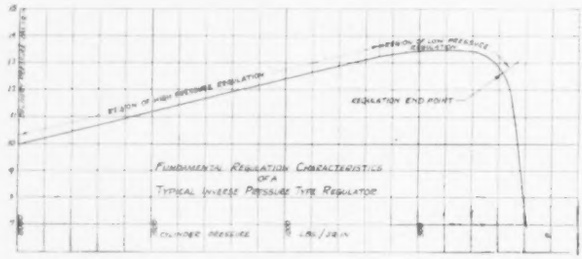


Fig. 3

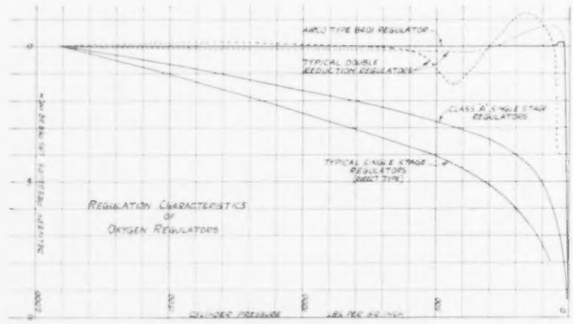


Fig. 4

Frictional disturbances are generally made evident by a considerable deviation of the regulation in the low-pressure region from theoretical performance and by sudden pressure readjustments in this region. Any attempt to minimize friction in a regulator by various mechanical artifices brings in another type of trouble which is variously known as "singing," "humming," or "chattering." An investigation of this phenomenon indicates that there is a natural tendency toward instability in the movements of the regulator seat and that if vibration of the moving parts in the regulator is to be prevented some damping means are necessary. Friction ordinarily supplies the necessary damping forces. The precise mechanism of seat movements in improperly damped regulators appears to involve the suddenly increased high-pressure gas thrust against the regulator seat in the region of the nozzle lip impression on the face of the seat when the seat is urged to a greater displacement by changes of gas pressure reaction against the regulator diaphragm. This increased thrust drives the seat yet further away from the nozzle and results in such an excessive discharge from the nozzle that the gas pressure beneath the diaphragm increases sufficiently to slam the seat violently against the nozzle. It does not appear necessary to go into further details concerning seat rebound, resonance conditions, etc. It is sufficient to note that unless there is a certain amount of damping, the movements of the seat may become so unstable as to result in very rapid repeated movements of the seat toward and away from the nozzle, which not only are troublesome because of the noise involved, but which may shorten the life of the seat. In the ideal regulator there should be no more than just enough friction to damp the seat movements when the heaviest flow for which the regulator is designed is involved.

Fig. 5

Static Increment and Creep

Closely allied with the theory of pressure regulation is that of static increment. By this is meant the amount by which the delivery pressure of a regulator in satisfactory working condition rises whenever the discharge from the regulator is blocked. This obviously is the pressure rise which is necessary in order to press the seat against the nozzle with sufficient force to stop the discharge of the high-pressure gas.

The question of static increment is important because for very low rates of flow the seat may not be displaced from the nozzle; the valve may permit a sufficiently large discharge simply by allowing the gas to seep between the seat and the nozzle while the two are in actual engagement at most points. Under these conditions it is found that a regulator with a large static increment is one that is very unsatisfactory in its ability to regulate the delivery pressure for small out-flows. In order to seal a nozzle hermetically against further discharge, the seat must be urged against the nozzle lip with sufficient force to stress the seat material in contact to a pressure which is at least as high as the pressure of the high-pressure gas. Otherwise the gas will seep through. In practice, it has been found that owing to such features as nonhomogeneity of the seat material, a considerably higher pressure is required. Thus it often is found that for service with gases at 2000 lbs./in.^{2}, the seat material must be stressed to a value higher than 3000 lbs./in.^{2} in the region of the nozzle lip. But if the compressive modulus of elasticity of the seat material is very low, then the seat movement necessary to realize this stress may be so great as to involve a considerable increase in the stress of the adjusting spring. Such an increase, of course, will only add to the static increment. On the other hand, a seat material with a very high modulus may be so hard that it will not readily conform to the shape of the nozzle lip nor care for dirt or foreign material which may sometimes be present.

If the regulator is not in satisfactory working condition there may be added to the static increment a further pressure increase which, in comparison, develops rather slowly. This is usually known as "creep." It may result from an imperfect design of the seat-carrying means, from the presence of dirt, scale, or other foreign material, or from the use of faulty seat material.

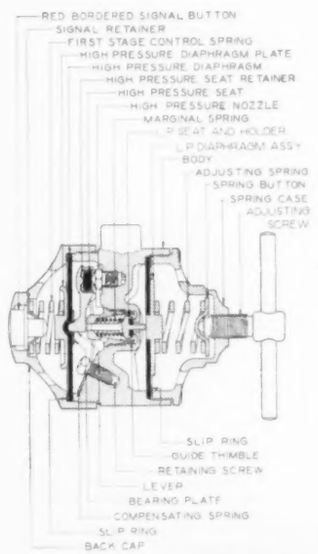
It of course is essential that the seat shall squarely and accurately engage the nozzle lip if it is to close the nozzle hermetically without the application of excessive force. Ordinary machining and assembly manufacturing tolerances are usually not sufficient to guarantee a square closure of the seat against the nozzle. It therefore is desirable in most designs to provide some special means for "seat accommodation" that will take care of reasonable manufacturing variations. For best performance it also is necessary to ensure what may be called "seat alignment." That is, it is necessary to provide means which will present the seat to the nozzle in such a manner that the nozzle lip impression in the face of the seat will be accurately fitted to the nozzle lip. Otherwise, with eccentric loose play in the movements of the seat as it engages the nozzle, the valve will continue to leak until sufficient pressure is developed to force a tight closure, and the regulator will tend to creep.

Fine woven wire strainers of 100 or 200 mesh are frequently employed at the regulator inlet in an attempt to collect foreign material. The results have been only moderately satisfactory, because the seat displacement is usually so small that particles which pass through the finest of wire strainers may readily be retained between the nozzle lip and the surface of the seat. Consequently, efforts have been made to prolong the life of the regulator seat by selecting seat materials which to a considerable degree will accommodate foreign particles by permitting them to become embedded in the surface of the seat when the latter is urged against the nozzle lip. Besides, there is a minimum modulus which is permissible in accomplishing this object since it has been found that a material such as Babbitt which will accommodate the foreign material by reason of a certain degree of softness is not very satisfactory, for if the mate-

rial is soft enough to accommodate these particles readily, it is too soft to prevent a slow plastic yielding when the seat is pressed tightly against the nozzle. The most satisfactory materials have thus been found to be those which possess a moderately low modulus of elasticity. The hardness should usually not be less than Rockwell B 90 (with a ¼" penetrator and a 60 kg. load). For many years certain organic materials such as caseinite and galolith were used for this purpose, but owing to their hygroscopic nature any moisture in the gas served to soften seats excessively under certain conditions. Subsequently, if the seat were permitted to dry when pressed tightly against the nozzle by the compensating spring while the regulator was not in use, it frequently cracked. If a regulator with such a seat is subsequently placed in service, the seat is incapable of stopping the discharge of high-pressure gas, and excessive pressures may develop within the regulator body.

Safety Features

A more serious type of seat trouble, but one which fortunately has been eliminated in modern regulator designs, is what has come to be known as "seat ignition." If oxygen at full cylinder pressure is suddenly admitted into an oxygen regulator by opening the cylinder valve, considerable heat may be developed at the regulator seat as a result of the heat of compression imparted to the gas originally in the regulator inlet passages. Inasmuch as the most satisfactory seat materials are certain organic materials, such as carefully selected grades of hard rubber, the heated oxygen in contact with the seat predisposes the latter to ignition. It only requires the presence of some small inflammable foreign particles as fuses or a highly roughened seat surface to cause the seat to burn. The result, of course, is that gas at cylinder pressure will suddenly be admitted into the body of the regulator.



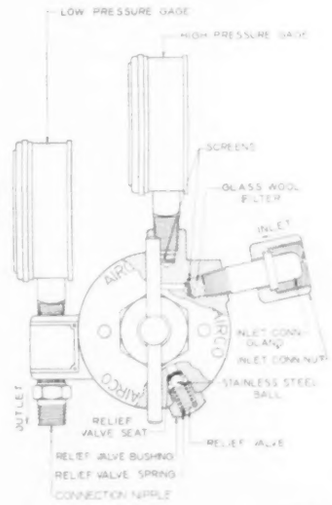


Fig. 6

Because of the possibility of suddenly admitting full cylinder pressure into the low-pressure cavity of a regulator as a result of cracked seats, seat ignition or heavy creeps, every regulator for welding service should be equipped with some type of safety release designed to vent the low-pressure chamber in the event that an excessive working pressure develops, and the regulator should safely withstand the sudden admission of full cylinder pressure into the regulator inlet when a regulator seat is not assembled in the regulator.

Fig. 7

In addition to such considerations, it would seem that every effort should be made to eliminate totally all of the various causes of serious seat leaks by selecting a non-hygroscopic seat material that will not crack when under stress and which is so resistant to ignition that under no conceivable conditions of use in the regulator can it be ignited.

PART TWO—SOLUTION

Development Program

After a careful and extensive preliminary survey of the practical requirements for a truly satisfactory regulator for high-pressure gases, the following research and development program was outlined:

1. To develop a two-stage pressure reduction regulator in which the optimum regulating performance is secured through the evolution of *(a)* a mechanism for the first stage of pressure reduction primarily suitable for high-pressure regulation; and *(b)* a second stage of pressure regulation primarily suitable for low-pressure regulation. It was decided to develop a two-stage regulator because it was known that such a regulator has better fundamental regulating characteristics and is freer from precooling disturbances. Although the future design was not visualized, it was believed that by careful attention to manufacturing problems a dependable regulator of this two-stage type would be developed which could be produced at a commercial price.

2. To develop a properly damped regulator, it having been observed that with most regulators the amount of damping secured varies widely as a result of normal manufacturing variations.

3. To develop improved seat accommodation and seat alignment means.

4. To develop a superior dust filter.

5. To eliminate the possibility of seat ignition.

6. To develop an improved seat material.

7. To develop a more satisfactory safety release.

8. To develop an improved flowmeter for gas regulators.

Apparently, satisfactory solutions were found for all the regulator problems discussed in this article. The results were finally incorporated in the regulator illustrated by Figs. 5, 6, 7 and 10.

(1) Improvement of Regulation—Fig. 4 illustrates the remarkable quality of fundamental regulation which may be obtained with this regulator (labeled "Airco type 8401 Regulator"). The deviation from the ideal is too small to be observed even on a mercury column until the cylinder pressure is extremely low. For cylinder pressures ranging between 2000 and 200 lbs./in.² the precision of regulation has been increased on the average about two hundred fold as compared with typical single-stage regulators. Even as compared with typical two-stage reduction regulators, the precision of regulation has been very measurably increased. This particularly applies to the region under 300 to 500 lbs./in.² The regulation end-point of this regulator is exceedingly low. It is possible to drain the cylinder pressure down to within a few pounds of the delivery pressure before the device ceases to function as a pressure regulator.

In arriving at these results it was found that:

1. Both diaphragms should preferably be as large as they can be made consistent with compactness of design.

2. The first stage of the regulator should be of the direct pressure type. It was found that fundamentally the inverse pressure type is at a disadvantage for high-pressure regulation, because other things being equal, a larger nozzle must be used with such a regulator in order to accommodate the thrust pin which must pass through the nozzle.

3. A lever principle should be involved in the first stage which will permit relatively small changes of delivery pressure to compensate for large changes of high-pressure gas thrust against the high-pressure seat.

That the mechanism evolved is capable of performing satisfactorily even in extremely cold weather is well illustrated by Fig. 7.

(2) Satisfactory Damping—In studying the problem of damping, it was found that damping in typical regulators of the type illustrated by Figs. 1 and 2 is of a very haphazard character. It arises from the lateral distortion or buckling of the helical springs when under compression. If the adjusting spring and the compensating springs, for instance, are distorted in such a manner as both to urge the seat carrying means in the same lateral direction then damping will be at a maximum, but if the lateral forces arising from these springs are opposed, then damping will be at a minimum. As illustrated by Figs. 5 and 6 (also visible in Fig. 9), a damping means has been provided which is uniform for all manufacturing assemblies, in which a crescent-shaped stamping of sheet spring steel (the compensat-

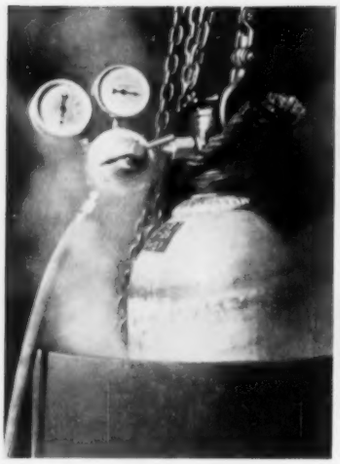


Fig. 8

Fig. 9

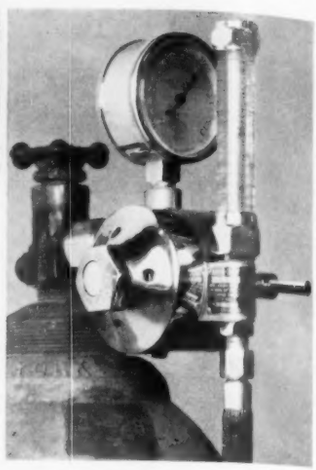


Fig. 10

ing spring) bears on the lever in a region intermediate between the projected center line of the nozzle and the two ball fulcrums on which the lever rocks. Thus a definite portion of the compensating force is utilized to effect damping at the lever fulcrums. The good performance of this regulator is due in no small measure to this feature. This is particularly true for extremely small rates of discharge. Thus it was found that during a 16-hour test run the regulator faithfully maintained a two liter per minute rate of discharge. It also has been found that the regulator lends itself to exceedingly precise pressure adjustments, there being no difficulty in adjusting the pressure to the nearest one hundredth of 1 lb./in.^{2} when a suitable water column is used for observing the pressure.

(3) Seat Accommodation and Alignment—Seat accommodation is provided by permitting the high-pressure seat to rock on a welt in the bottom of the seat-carrying cavity at the end of the lever, the seat being retained in position by a resilient metal seat retainer. Positive seat alignment is secured through the design of the lever and compensating spring assembly in which the rounded ball fulcrums of the lever are urged to the lowest possible position in the conical fulcrum cavities machined into the regulator body, thus eliminating all loose play.

(4) Glass Wool Dust Filter—A carefully selected grade of glass wool was found to be the most effective dust filter aside from such inflammable and hygroscopic materials as wool and cotton felt. The glass wool is not only free from the ignition hazard that is involved with inflammable filters but being non-hygroscopic it always remains resilient. It is apparently by virtue of its resiliency that it never cakes over with dirt and scale in the manner that a metallic strainer does. Even after three years of severe service, a regulator equipped with an experimental filter of this type has been found to offer no measurable restriction to the flow of the gas, although when opened the rear end of the filter was found to contain almost a thimble full of fine dirt and scale. During this interval there had been no seat failures. The effectiveness of this filter may be readily demonstrated by pouring fine iron or brass filings into the inlet of the regulator: the regulator continues to perform satisfactorily indefinitely although this same treatment would at once render the average regulator inoperative.

(5) Elimination of Seat Ignition Hazards—The glass wool filter not only eliminates frequent seat replacements, but by preventing inflammable foreign material from reaching the regulator seat, it removes one of the contributory causes of seat-ignition. The fundamental cause of excessive temperature rise at the seat surface, moreover, has been completely removed by creating a cul-de-sac or dead-end pocket beyond the regulator seat. Fig. 6 shows such a pocket under the high-pressure gage and a passage from this pocket communicating with the regulator nozzle. The effectiveness of this construction depends upon the fact that the heat developed in any passage suddenly flooded with high-pressure gas is localized in the extreme end of the passage. This phenomenon may be explained as follows: Let it be assumed that a full oxygen cylinder pressure of 140 atmospheres is suddenly applied to the oxygen within the high-pressure passage of the regulator. Also assume the oxygen in this passage to have been practically at atmospheric pressure previous to the application of the 140 atmospheres of pressure. If there were no intermingling of the gas from the cylinder with that which was already in the high-pressure passage, these conditions would result in a temperature rise of nearly 1700°F. Of course, the actual conditions of flow of the gas through the regulator passage result in an intermingling of the two bodies of gas to such an extent that a much more moderate rise of temperature is the usual result.

In order to perceive clearly the nature of the phenomena involved, it must be observed that the gas which had occupied the entire inlet passage has been reduced to 1/140th of its original volume. This small amount of hot gas has been diluted with gas from the cylinder. The latter is practically at room temperature except for the effect of the heat it has abstracted from the hot gas, because although it has undergone an approximately adiabatic expansion in flowing from the cylinder, during which its temperature dropped to a very low value, it immediately thereafter underwent an adiabatic compression in which its temperature was restored practically to its original value.

In actual practice the dilution of the hot gas is seldom uniform. Apparently, the warmer portion of the gas is pushed to the end of the passage, namely to the seat surface in the usual type of regulator construction or into the dead-end pocket in the case of the regulator covered by this description.

The effectiveness of the construction adopted is illustrated by Fig. 8 which shows an oxygen cylinder and regulator (the latter equipped with dead-end pocket) being withdrawn from a bath of water heated to 190°F. The regulator and oxygen cylinder were immersed in this bath for one hour, and then hot oxygen at a pressure of 2500 lbs./in.^{2} was suddenly admitted into the regulator from the cylinder. Although many different highly inflammable seat materials and inflammable substances within the nozzle were tried, it was found to be impossible to bring about seat ignition in regulators of this type. On the other hand, it was found easy under most normal conditions to ignite seats in a regulator similar to the one illustrated by Fig. 2 when the temperature of the water bath was no higher than 90°F.

However, in order that there might be no doubt that seat ignition had been entirely eliminated, a type of seat material was ultimately selected which resists ignition even when heated to temperatures much higher than were possible in the hot water bath test. Since the dead-end pocket principle was first employed in regulator construction, tens of thousands of regulators have been manufactured employing this means of seat protection, and not a single instance of seat-ignition has been reported.

(6) Selection of Seat Material—As previously pointed out, there are many other properties aside from resistance to ignition which are important for seat materials. With careful attention given to all of the practical as well as theoretical requirements, a seat material was eventually selected which has proved its ability to withstand years of severe service. When used in the two-stage reduction regulator equipped with the glass wool filter, the result is practically an "everlasting" seat. The abuse which this seat will withstand is illustrated by Fig. 9 in which it will be observed that a rather deep cut can be made across the face of the seat without as a rule causing the seat to leak.

(7)—Safety Features—The first stage cavity of this regulator is equipped with a relief valve which will prevent excessive pressures from being developed within the regulator. If an excessive pressure tends to develop down-stream from the regulator as a result of a disturbance in some other source of supply or because of a backfire, the second stage seat will lift from its seat and permit the excessive pressure to be relieved through the first stage cavity and from thence through the relief valve.

(Continued on page A11)

Flow Measurement and Control*

By M. F. BEHART†

CHAPTER XXIII—POSITIVE METERS

POSITIVE GAS METERS

10. Bellows Meters

(Continued)

(h) Precision, Portable and Special Models

For permanent installations where extreme precision is desired, it is recommended that the user specify the meter which appears to be the most suitable with respect to characteristics other than accuracy: in other words, to work under the assumption that all bellows meters are instruments of precision. Then, a meter having been thus selected, its manufacturer is asked to take special pains in its final adjustment before shipment, and if the user has a meter prover, the meter is carefully proved before being installed.

This recommended procedure avoids the onerous job of attempting to determine which of several makes is "the most accurate." It results in a satisfactory selection in the majority of instances. The exceptions are few, and they consist of applications differing from the usual gas measurement application in the metering conditions. For example, the problem of measuring a gas mixture which varies in its volatile constituents, thereby affecting diaphragm leather pliability as discussed in Art. **(a)**. Likewise, metering a dry gas in a seasonal industry, the meter standing idle five or seven months of the year and going back into service without being proved—the plant lacking proving facilities and everyone being too busy when operations are resumed. Also, metering gases being tested for volatile content—which the meter leathers must not alter.

For such exceptional cases the proper way of specifying the right meter is to invite the coöperation of meter manufacturers and obtain their proposals and guarantees—and not to start with the assumption that a particular type of bellows meter is the logical choice. Reliable and in many respects desirable as are bellows meters, the investigation may bring out that none will do: the answer may turn out to be a wet meter, in spite of the fact that wet meters require attention many times more frequently.

Portable Test Meters.

Although these find their largest sale in the gas industry itself (for testing consumers' meters), some of their industrial engineering applications (unrelated to the actual "testing" of meters or other apparatus) are of extreme importance. In general design, most portable test meters resemble the small-capacity Glover type meters described in Arts. **(e)** and **(g)**, differing only in details of construction. The principal differences are (1) large dial registers and (2) hand-holes with screwed—not soldered—cover plates for easy adjustments. Note, however, the last two described below, which differ both in design and construction from the Glover type. There are tin case portable and semi-portable test meters for low-pressure gas measurement, as well as aluminum, pressed-steel and iron portable and semi-portable test meters for medium-pressure work. Among those of engineering interest are the following:

Superior Meter Co. This company's portable test meter is a standard "150-B" (see Table XXIII-3) provided with a carrying handle, a large removable hand-hole plate in the top cover, and an enameled-dial four-circle register reading from 0.01 cu. ft. to 1000 cu. ft. All four hands can be set back to zero. Net weight, about 16 lb. Regular finish, red paint and polished brass—an excellent idea!

Pittsburgh Equitable Meter Co. Six sizes of aluminum-case test meters with large eight-circle registers of which the hands can all be set back to zero. Only

*Part Six of *The Manual of Instrumentation*.
†Editor, *Instruments*.

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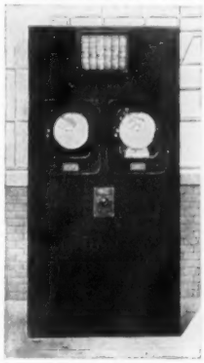

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SYSTEMS to regulate pump speed, reheat temperature, desuperheat and other factors.

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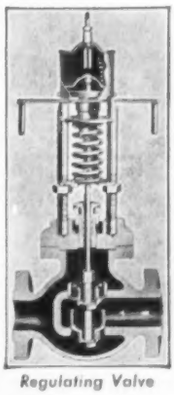

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G-1

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MANUFACTURERS' LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

A239 **Power Fuses.** 4-page Bulletin L20588 gives details of Type BA "De-ion" fuses up to 23,000 volts. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

A240 **Gas Measurement Devices.** Specification bulletin on Base Pressure Index and Base Volume Index which applied to gas meters, correct for variations of pressure, of temperature or of both. American Meter Co., New York City.

A241 **Opacimeter.** 6-page folder and 5-page mimeographed technical description of instrument for determining paper opacity. Bausch & Lomb Optical Co., Rochester, N. Y.

A242 **Surge Protection.** 96-page bound collection of bulletins on arresters, meter protectors, "De-ion" protectors and relief gaps, cutouts, links, etc. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

A243 **Combustion Control.** Bulletin 210 covers MJL No. 27 regulators. Morey & Jones, Ltd., Los Angeles, Calif.

A244 **Instrument Transformers.** 64-page catalog containing technical information, ratio and phase angle curves, and full descriptions, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Penna.

A245 **Automatic Sign Flashers.** 24-page catalog describes cyclic "Kontrolers" and gives wiring arrangements and other data. The Leland Electric Co., Dayton, Ohio.

A246 **Refrigerator Controls.** 12-page Bulletin 1063 covers "Snapon" controllers and kindred accessories. Bulletin 1050 covers the new Bakelite case dial thermometer. C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.

A247 **Resistance Split-phase Motors.** Leaflet 20580 on improved line. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

A248 **Hair Hygrometers.** Circular 108 describes three new indicating and three new recording models, some combined with thermometers. Amthor Testing Instrument Co., Brooklyn, N. Y.

A249 **Counters and Count Controllers.** Two leaflets and a 4-page bulletin on new models. Production Instrument Co., Chicago, Ill.

A250 **Indicator Valve.** 4-page Bulletin 1267 on new Maihak valve for Diesel engine indicators. Bacharach Industrial Instrument Co., Pittsburgh, Pa.

A251 **Baliopticons.** 24-page booklet on various types and their accessories. Bausch & Lomb Optical Co., Rochester, N. Y.

A252 **Temperature Control.** Broadside on pyrometric potentiometer controller. The Foxboro Co., Foxboro, Mass.

A253 **Resistometer.** Leaflet F-120 on four-purpose checking equipment. Thwing Instrument Co., Philadelphia, Pa.

A254 **Portable Testing Equipment.** 4-page Bulletin GEA-1754 on testing sets and induction voltage regulators. General Electric Co., Schenectady, N. Y.

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the three smallest sizes (400, 550 and 800 cu. ft.) can be said to be portable; the shipping weight of the largest (5000 cu. ft.), for example, being 300 lb. These capacities are all at 2″ drop. The entire mechanism of each of these meters is readily accessible, being assembled on a valve plate casting as explained in the description of the "Emco Large Capacity" industrial meters (Fig. 23-85).

American Meter Co. Two sizes of portable tin case meters with removable hand-hole plates and registers reading from 0.01 to 1000 cu. ft. Hourly capacities at 0.5″ drop are 150 and 300 cu. ft. Also two sizes of tin-case semi-portable test meters designed especially for testing large-capacity service meters:

Size	Hourly capacity — Rated	Hourly capacity — 2″ drop	Net Weight	Pipe connections
11-C	1120	2400	65	2″
25-C	2500	5500	122	2½″

Both have 6″ enameled-dial five-circle registers reading from 0.01 to 10,000 cu. ft. (zero-set hands) and indicating hourly rate on a "minute observation" circle. (See Fig. 23-92.)

Fig. 23-92

Fig. 23-93

Also two sizes of small and truly portable test meters of special design. These are both of the three-diaphragm four-compartment type with centrally-located rotary valves. The "AS-6" (Fig. 23-93) weighs about 8½ lb and has an hourly capacity of 20 cu. ft. at 0.5″ differential. Its register reads from 0.001 to 100 cu. ft.; it can be used for precision metering of extremely small flows—down to about 0.5 cu. ft. per hour—and therefore appears to be what is required by those engineers who wish that they could take out for field work the familiar wet test meters (§12) found in nearly all laboratories. In fact, this meter is a standard part of the portable form of Oberfell Apparatus and of other portable outfits which in their laboratory forms usually include a wet meter. The "AS-7" has an hourly capacity of 65 cu. ft. at 0.5″ drop and its register reads from 0.001 to 1000 cu. ft. It has a connection to which a thermometer or a manometer can be attached.

(i) Auxiliary Instruments

For engineering work where all factors are desired to be known, as well as for regular metering service where more data are required than the mere volumetric registration, bellows meters are equipped with auxiliary measuring devices which augment their usefulness considerably. Recent years have witnessed the appearance of many such instruments, some designed and manufactured by gas meter manufacturers for their own meters; others brought out by industrial instrument firms experienced in the production of recording instruments; others supplied to meter manufacturers by electrical instrument makers.

The necessity for most of these auxiliaries is caused by *variations* in the properties of the metered gas. Other auxiliaries (the demand devices) are needed chiefly for price-rate and other business reasons, but find some engineering uses as well.

Pressure Instruments

Pressure variations being the most serious in their effects (see §8), the great majority of bellows meter auxiliaries are pressure measuring instruments. Indicating manometers or dial gages are used as adjuncts to test meters, but seldom in connection with regular service meters.

Recording pressure gages are indispensable adjuncts of most industrial meters and of all large-capacity meters except where conditions are so favorable that regulators can be relied upon to hold the desired pressure within close limits. These recording pressure instruments may be classified according to the forms of records which they provide:

Let us first consider the ordinary recording pressure gage, with a clock-driven chart and one pressure pen. Obviously, this class of instrument, although "better than nothing," furnishes incomplete data. For example, a 7-day chart may show that the line pressure averaged 250 lb from Monday to Thursday of a certain week, 300 lb on Friday and Saturday, and 350 lb all day Sunday; but without knowing the volume registered by the meter

Fig. 23-94

during each of these periods we cannot calculate the actual quantity (in standard cubic feet) that was consumed.

Requiring, then, data on both volume and pressure, let us modify our ordinary pressure recorder in such manner that its chart is driven not by a clock but by the gas meter itself. The result is a class of instrument exemplified by the Wylie Pressure and Volume Gage (Pittsburgh Equitable Meter Co.), one model of which is shown in Fig. 23-94. The gearing is so arranged that the chart makes one revolution for each 100,000 cu. ft. (or other multiple of 10 for convenience) and the average pressure can be read for each 100 or 1000, etc., cu. ft. of gas registered by the meter—this unit of volume depending on the amplitude of the recorded variations: for example if on a "million" chart it shows constant pressure from 150,000 to 850,000, this whole section can be taken as one increment and only the two end sections need be closely computed. With this class of instrument a definite schedule of chart-changing calls is unnecessary: if the chart has not made a complete revolution at the time of a call, the number of cubic feet recorded is simply read off as the length of the pen trace in volumetric graduations (the angular divisions of the chart). This can be checked against the meter register increment since the previous chart-changing call. If the chart has made one complete revolution and part of another, the record is still discernible.* This instrument is available in 8″ and 12″ chart sizes and in eleven ranges, including two extending below atmospheric pressure. Installation on a meter is generally simple enough to be done without special tools.

Somewhat more elaborate than the foregoing is a class of recording instruments provided with two pens, both recording or one clock-driven chart (24-

*Even if the line crosses itself and forms "islands" or "loops," the chart computer need not be at a loss in applying factors. Moreover, it generally does not matter whether he assigns all "highs" to the beginning and all "lows" to the end, or vice versa.

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INSTRUMENTS BOOK SHELF

Experimental Physics for Colleges. By Walter A. Schneider and Lloyd B. Ham. New York, The Macmillan Co., 1932. Cloth, 5½ x 8½ inches, 259 + x pages. 163 figs. Price $2.25.

"This book," declare the authors at the beginning of their preface, "is essentially a *text* on experimental physics for elementary students." (Italics theirs). But in Chapter IV on Statics they say that "the coefficient of friction is found. . . . *The proof for this can be found in almost any physics text.*" (Italics ours). Turning back to the preface we find the authors explaining that "This book can be used as a laboratory text in conjunction with any general college physics text."

What this book is, actually, is a school physics manual of experiments—and an excellent one. The experiments are selected with an insight into the modern student's mind which amounts almost to genius. Most of them are designed for a full two-hour period. The apparatus is generally inexpensive, but that "many pieces of apparatus mentioned in this text may be made cheaper and often better than those which can be bought, provided the facilities of a machine shop are available" is open to question. (The reviewer, for one, doubts that this is true of "many.") Seldom, by the way, is the apparatus itself described: in most cases the illustration is either a conventional diagram or a cut from the Central Scientific Co.—the choice being apparently governed by expediency, as on pages 99 and 123 where, in our opinion, diagrams would have been preferable. Although the book as a whole does not qualify as a serviceable physics text (*i. e.*, for self-study), the introductory paragraphs of several chapters do combine definitions and interpretations into readable presentations. Examples, "Periodic Motions," "The Measurement of Resistance" (in which the authors properly warn against confusing a potential divider with a potentiometer), "Thermocouples," and "The Diffraction Grating." Some of these are gems of exposition, in that they grip the reader's attention as few school science books do. Congratulations to the authors for such touches as "Just imagine how interesting it would be if our eyes could see dimensions the size of molecules." They are both "modern" professors who evidently know how to write lucidly and entertainingly, and we regret, therefore, that they failed to liven up dry spots. Chapter II, on "Precision of Measurements," is so dull that ordinary young men will probably get little out of it, so dry that we suspect the authors of including it perfunctorily. Certain it is that this chapter was not even proof-read carefully: The omission of a decimal point in such an example as

1.8%
13%
Answer 1.8%

on page 9 (where the student is taught to retain the largest percent error) sticks out like a sore thumb. But perhaps the dullness and dryness of Chapter II, and of a few passages elsewhere, are only comparative—by reason of the delightful lucidity of the greater part of the explanatory matter. Even Chapter II is no worse than the corresponding chapter in nine out of ten "Experimental Physics." Anyway, none of these criticisms applies to the directions: these are invariably excellent—and since the directions in a compendium of school laboratory experiments are the most essential part thereof, this book, on the whole, can be heartily recommended as an excellent manual, supplemented by "extras" in the form of many good paragraphs of straight physics text.—M. F. Behar.

(1.2)-B-

The Principles of Optics. By A. C. Hardy and F. H. Perrin. McGraw-Hill Book Co., New York, 1932. Cloth, 6x9 inches, 618 pages. Price $6.00.

In their initial chapter the authors state in justification of their treatment this view: "That a theory represents a

hour or 7-day). Unlike the foregoing, this class of instruments usually embodies a special register so that the entire assembly can be installed on a meter by substituting it for the regular register. The pressure pen performs its usual function; the volume pen records volume against time in the form of increment waves on the edge of the chart by reason of its being caused to oscillate back and forth by the meter register mechanism.

This form of volume record, by the way, can serve as a "load" or a "demand" record (eliminating in some cases the necessity for another class of auxiliary device) since the closeness of the waves shows at a glance the average rate of flow over any period covering several waves, and even the slope

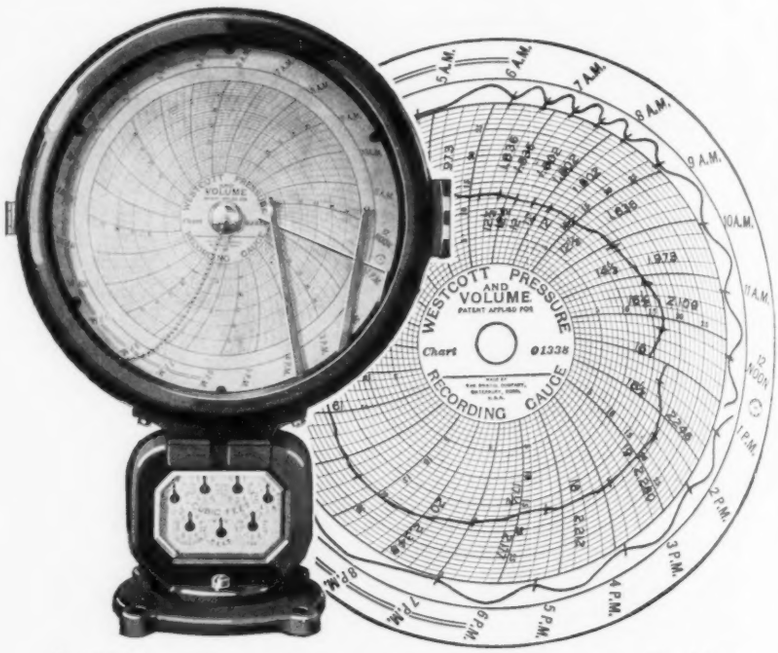


Fig. 23-95

Fig. 23-96

of a portion of one wave can be interpreted in terms of rate of flow over a short period. (Obviously, when the meter register is not turning, the volume pen stands still and traces an arc concentric with the chart printing.) The volume pen is connected to any specified pinion of the register. In specifying this, the unit of volume selected should be of a value which, when the meter operates at capacity load, will not crowd the waves so much that they cannot be discerned one from the next. This same consideration is taken into account also in specifying the chart period: 24-hour or 7-day. (Note however the selective action of the Emco volume pen, next paragraph.)

An instrument of this class may be seen in Fig. 23-85. It is the Emco Combined Record Gage (Pittsburgh Equitable Meter Co.). The volume pen (not clearly visible in the photograph) records on either of two concentric zones near the chart edge: For all rates of flow from normal to capacity, this pen is actuated by, say, the 10,000 cu. ft. element of the register; whereas at low rates of flow it is changed over to be actuated by, say, the 1000 cu. ft. element. This instrument is available in four ranges, up to 500 lb, all in 10″ chart size.

Another instrument of this class is the Westcott Volume and Pressure Gage (American Meter Co.), Fig. 23-95, available in nine ranges including one extending to 30″ vacuum; and Fig. 23-96 not only shows the form of record obtained therefrom but gives an idea of the method of chart computation.

Combination Offer Saves $1.00

When renewing your subscription—or when sending in a new subscription for a friend—take advantage of the combination of one-year subscription and a copy of "Fundamentals of Instrumentation" (see ad on page A8) for $3 instead of $4.

INSTRUMENTS PUBLISHING CO.

special case of a more general principle should not be an objection to utilizing it for what it is worth, especially in a book whose emphasis is laid on the application of theories rather than on proofs of their validity." This standpoint is certainly praiseworthy, but surely it is not distinctive. In the books of Drude, Houston and Wood, the unifying principles of electromagnetic theory which are not treated at all in this book, are only taken up after the resources of geometrical optics and wave theory are successively explored. What distinguishes this book from those mentioned is that the applications of these two branches of optical theory are gone into in more detail. In plan the work closely resembles Nutting's "Outlines of Applied Optics," which is enough to recommend it.

The treatment of geometric-optical theory, it seems to this reviewer, suffers from certain easily remediable defects. Like Taylor they reckon distance in opposite directions in image and object space. While familiar to us from high school physics this convention conflicts with that found in most of the literature in which distances are nearly always reckoned positive to the right. The outstanding exceptions, the systems of Schwartzschild and Taylor, have been reformed by Gardiner (Sci. Paper 550, Bu. of Stds.), and it would seem a disservice to educate students in a system so little used. The question is not only one of conformity however; unless a fixed direction is chosen as positive there are no expressions invariant under refraction at a spherical surface like the image and stop invariants. Moreover, the equation

$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$$

expresses in the most widely used convention the fact that a lens adds the curvature $\frac{1}{f}$ to the curvature $\frac{1}{u}$ of the incident wave. The expression

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

expresses the same thing in the authors' system. In which is it better expressed?

The notation in the diagrams could be improved by adopting the convention that one indicates between arrow heads only positive quantities. Had the authors done this the diagram on page 15 would have had $-\theta'$ where θ' is written and the juggling with signs at the top of page 35 could have been avoided. If this diagram convention is adopted much of the awkwardness of the standard sign conventions disappears. A disastrous attempt is made to reduce the definition of the magnification of a telescopic system to that of a projection system, culminating in a fallacious argument based on the assumption that the ratio of two quantities which become infinite is unity.

The treatment of the thick lens and of apertures are more fortunate and rather full. In treating of lens aberrations the authors consider the algebraic method as "unduly involved" and "of slight practical value." This view is heard often expressed and it would seem that this method is only appreciated in quarters where genuinely new designs originate. In optical as in other design one has mostly to adapt accepted patterns to new conditions, and in this work the calculation is indeed chiefly trigonometric. One is reminded of the still more radical view of the working optician Grubb that "objectives cannot be made on paper." And if one were to ask the sales manager one could doubtless arrive at still another view as to who "makes" objectives. When lenses can become popular on account of their "softness" and "depth of focus," who can judge among all these rival claims?

The authors nevertheless give an instructive discussion of lens aberrations including a table and some graphs of spherical aberration in the case of a single lens of various shapes. A useful table is given of the constants in the Hartmann formula for quartz and fluorite. Those for several glasses are also given, but unfortunately for glasses listed under the old Schott numbers which do not usually correspond to glasses now listed.

The chapter on the resolving power of optical instruments is adequate to render understandable the observed diffraction phenomena. It does not go deeply into the mathematics, but gives sufficient references for those who wish to do so. The chapter on radiation and radiometry is rather sketchy, but that on light sources should prove useful, as it includes numerous graphs and tables covering the energy distribution of natural and artificial light sources. In treating of the eye, not only the geometric optics but also the variation of pupillary diameter and variation of contrast sensibility with brightness are dealt with. The chapter on photography is quite extensive and summarizes in 45 pages much of the older as well as the more recently published work.

In treating light sensitive cells, in which field the authors have had considerable experience, selenium and photoelectric cell data and curves are given, at least for the General Electric makes, and the problems arising in amplifiers are dealt with. In the later chapter on photometry the Hardy recording color analyzer is described in some detail.

Chapter XV on optical glass gives a brief résumé of the technology of glass making and testing and an abbreviated glass test. One misses the glass chart which is usually included by writers on this subject. The chapter on the manufacture of optical parts is useful to read before a visit to an optical shop. The chapter on the testing of optical parts while suggestive is too brief to be satisfying to the laboratory worker. The chapter on miscellaneous optical materials is a very valuable one. Data are given for glass filters and the refractive indices of quartz, fluorite, calcite, water, and CS_2 in the ultra-violet and of quartz, fluorite, rock salt, sylvite, and CS_2 in the infra-red, and a very inclusive table of reflectivities of metals and alloys is given. The chapter on the design of optical instruments treats of the size and position of the pupils and of the mechanical design, a subject very seldom touched on by other writers. In treating of spectroscopic apparatus it is erroneously held that the Pellin-Broca prism causes a displacement of the ray when rotated. It was shown by Uhler that, when suitably mounted, this can be completely avoided. The use of left and right turning quartz in prisms for the ultra-violet is mentioned, but not explained. Another slip occurs in the chapter on interferometers where the adherence of gage blocks is attributed to air pressure.

The book will be an invaluable reference work to the optical worker at his desk or in the laboratory. Its full detail practicality and suggestiveness will make it for the American reader perhaps the first reference to go to when in doubt on the next point of procedure. There are numerous citations of the recent American literature—indeed one might give as a fault its too close adherence to these. The book does not go deeply into fundamental theory. There is no reference to a theory of dispersion nor to the Sellmeier formula. In its excellent index one looks in vain for the Kerr and Faraday effects which are by no means unimportant today. But the field of optics is so large that the reader can afford to overlook these omissions.—S. Jacobsohn.

(7.1)-B-

The Measurement of Air Flow. By E. Ower. London, Chapman & Hall, Ltd., 1933. Cloth, 5½ x 8½ inches, 243 + viii pages. 85 figs. Price 15 shillings.

This is the second edition of the book which, as our readers remember, ran serially in *Instruments* in 1930-31 and attracted much attention. It is not only more up-to-date but more comprehensive. The author has added some thirty pages on primary elements other than Pitot tubes, mostly, of course, on the uses of the sharp-edge orifice not only in round pipes as a concentric orifice but as a wall orifice discharging from a vessel (of any shape) to the atmosphere; also on the Venturi and on the flow nozzle. Naturally, he has drawn on the A.S.M.E. and other American sources for his treatment of the Venturi; but he still shows a preference for German writers whenever he has to go outside of England. And in the important chapter on The Design of Pitot and Static Tubes he casts not a single glance beyond the shores of his native isles—and few beyond the confines of the National Physical Laboratory! If this second edition, like the first, did not aim at being of practical every-day value to engineers, this would not call for any particular comment, but in his Preface to the Second Edition Ower states that "a completely new chapter (the last) has been added to meet criticisms leveled against the first edition on the score that it was not of a sufficiently practical nature." Now, this supplemental chapter is made up of typical examples from practice, with methods of calculations given in detail, and in this respect it is distinctly useful; but the examples are limited to some of the methods of measuring air flow which Ower describes in some of the preceding chapters. It would perhaps have been better to revise the book by inserting *these* examples in smaller type (the type is all large) immediately after the methods in question, and by adding a final chapter of *other* examples including "how they do it in the U. S. A." This would perhaps have been better for European engineers. American engineers having access to the transactions of the A.S.M.E. and A.S.H.V.E., and to *Industrial & Engineering Chemistry, Heating & Ventilating, The Aeroplane, Engineering & Mining Journal,* and other American technical journals, will find Ower's new book a valuable supplementary reference, comprising the author's own findings (largely from his noteworthy work at the National Physical Laboratory) and the cream of other English and German writings on air flow measurement. The chapter on Manometers (which we would call *micro*-manometers) was excellent even in the first edition, and as revised it is by far the most informative discussion which the reviewer has seen of devices for precision measurements of small air-pressure differentials. All in all, "Ower's Air Flow" has now won a place as a classic of technical literature.—M. F. Behar

(2.5)-B-

Handbook of Measuring Instruments (Handbuch der Messinstrumente). Vols. I & II. Atlas-Verlag Dr. Alterthum & Co., Berlin, 1933. Cloth, 6x9 inches, Vol. I, 126 pages; Vol. II, 144 pages. Price 20 R.M.

These books were published to give information on the German companies (about 500) furnishing measuring instruments and tools. Vol. I has 38 pages devoted to brief technical discussions: Vacuum technique by H. Ebert; Physical measurements on liquids by Hans Charas; Directions for Oversea Export by H. Botsch. This latter discussion urges German companies to go after overseas markets more vigorously. The reviewer feels that while Dr. Botsch evidently has America in mind, American companies have not given the possibility of exporting their products the consideration it deserves. At the present moment the American instrument industry should gird itself for the battle for its share of the foreign markets. Forget the inferiority complex. American instruments are the best there are, bar none.

Another section of the book lists the companies manufacturing measuring instruments for liquids, gases, steam and steam generation, and temperature measurement, by geographical location. Then there is an alphabetical list of companies.

Vol. II contains articles on electrical measuring instruments by R. Jaeger, and on energy measurements by Hans Charas; and the rest of the book is devoted to the companies manufacturing measuring instruments for electricity, magnetism, optics, vibration, solid materials, power, output, speed, length, area and counters.—Richard Rimbach.

(12.5)-B-

Photoelectric Cell Applications. By R. C. Walker and T. M. C. Lance. London, 1933, Sir Isaac Pitman & Sons, Ltd. Cloth, 5⅛ x 8½ inches, 193 x viii pages, 111 figures Price $2.50.

This book was written by two engineers associated with the British General Electric Co. They give some of their "own experiences" with the modern or conventional form of "alkali metal photoelectric cell," and in particular with that type known as the "caesium oxide cell." They add: "A portion of the book has already appeared in serial form in *Wireless World*," and enlarged upon in the present work.

It is interesting to note here that they do not hyphenate "photoelectric" as some authors are accustomed to do. Further, the term "photocell" as accepted by the Standards Committee of the I. R. E. is also used throughout.

The authors deal "exclusively with the alkali metal cells, chiefly because they have most acquaintance with them and prefer to record their own experience rather than the hearsay evidence of others." In view of this fact, the reviewer will not take them to task for not including other forms of light sensitive cells, such as the photo conduction, and photo voltaic (wet and dry). Moreover, they say that "there is no reason, in many cases, why other types of light sensitive devices could not be equally well employed with some modification of the circuits given." After all, the modifications referred to are slight changes, merely to match the input characteristics with respect to the impedance of the grid circuit, so that the greatest efficiency of the circuit may be had. The book deals, then, with that specific type of cell in which the alkali metal is used either in an evacuated bulb or in the presence of an inert gas at low pressure.

Chapter I is a rather sketchy review of the historical development of the photocell. The authors take a sudden jump from the work of Hallwach to the modern caesium oxide cell without discussing the gradual development to the modern photocell. The average reader might infer that this development was a sudden outburst rather than a gradual evolution. However, since the work was intended primarily as a "practical guide" and not one of historical interest, we shall have to be content.

Chapter II presents eight different ways in which the cell might be placed in the grid circuit of a vacuum tube, with short sub-chapters dealing with the thyratron and grid-glow tubes and the conventional form of "telephone relay." The authors would have done well to present a detailed study of these devices in a separate chapter since these units play a most important part in the circuit, and their proper functioning has not been properly considered by the workers in this art. The thyratron and the grid-glow tubes are used extensively in the U. S. by the General Electric and by the Westinghouse companies in their respective units. By means of these devices, electro-mechanical relays and all their attendant difficulties are dispensed with. For this specific reason we had hoped that American readers would get a more comprehensive study of these devices. It is pointed out that the chief difficulties experienced with relays in photoelectric units are contact troubles, slow reaction, etc. With thyratron and grid-glow tubes one can operate circuits directly since they are "electronic relays" handling sufficient current to operate devices directly.

All too short is the sub-chapter on the use of "light sources" which is as important a subject as relays and which can hardly be overlooked by the serious worker.

Chapter III deals with *counting* and *timing gear*. This chapter is very short and deals with generalities. A detailed description, however, is given for selective counting of newspaper bundles, *i. e.*, differentiating between small and large bundles. The recording of objects moving in one direction or in the opposite direction, which was recently demonstrated by the engineers of the (American) General Electric Co., is interestingly discussed. Timing of racing fields is next discussed, also a method of measuring the speed of rotation of shafts by means of a disk which has segments of different areas: the light falling on the disk is intermittently reflected on the photocell, and this is amplified and a record is obtained on a photographic oscillograph.

Chapter IV deals with *alarms, indicating* and *safety devices*, a subject which has attracted a great number of workers in the United States. A "locking in" type of relay is used for burglar alarms, so that only those acquainted with the device can open the circuit and discontinue its function when not required. Several interesting and novel ideas are shown for tell-tale alarms. The detection of poisonous gas, by means of discoloration of a fluid and a change in its transparency operating the alarm, is discussed—a system which was introduced in the U. S. with some success several years ago. The detection of smoke, like burglar alarms, is another subject that is given considerable attention, as are several other interesting applications such as alarm for water gages, a tell-tale alarm used in the production of paper bag printing, etc.

Chapter V deals with *advertising* and the first application is the playing of music, etc., over a beam of light ("photophone"). The control of signs with day-break and night-fall is next discussed. The operation of a window display sign by waving the hand is next illustrated. Under the sub-title of *novelties* we find an application whereby when a leaflet is taken from a stand it blinks a light source, also the operation of a drinking fountain, the control of model boats and cars, etc.

Chapter VI deals with the British *talking picture "heads"* (systems for reproducing sound from film). The mechanical and optical systems are somewhat different from the American practice and present no new methods. In this field the United States is further ahead than England.

The *transmission of pictures* ("phototelegraphy") is dealt with in Chapter VII. The essentials are first discussed, and then the most successful of the methods are described, omitting the synchronization method. Chapter VIII deals with *television* rather vaguely. As in the previous chapter, the synchronization method is left out and so the reader has to take it for granted that it is accomplished. We had hoped that details would be given of this important phase of still or moving picture transmission. Chapter IX deals with *scientific instruments*, and the discussion of the microphotometer is first opened up, then measuring the density of photographic films, and the rest of the chapter is devoted to photometry. Chapter X deals with *miscellaneous applications*, and these are confined to the use of the cell as an oscillatory circuit, *i. e.*, as in the case of the neon oscillatory tube circuit. The *bibliography* has five references to standard works on the subject of photoelectricity, and thirty-six references to the literature.

The authors unquestionably have produced a fine and most interesting book on the subject, but we had hoped that they would have told us more of their practical experiences, which would be so valuable. For all that, the book is deserving of a place in any worker's library for whatever "meat" he can pick out from the pages.

—Samuel Wein (5.3)-B-

Industrial Electrical Measuring Instruments. By Kenelm Edgcumbe and F. E. J. Ockenden. Pitman Publishing Corporation, New York, 1933. Cloth, 5½x8¾ inches, 553 pages, 392 illus. Price $7.50.

This is the third edition of a volume of the same name, whose second edition appeared in 1918, under the authorship of K. Edgcumbe. The text has been entirely rewritten, and the various sections considerably expanded, particularly that dealing with Instrument Transformers. Integrating meters are not touched upon; and the sections on Pyrometry, Potentiometers and Oscillographs have been omitted "on the ground that such instruments now hardly come within the scope of the title." In the interests of "practical" men, to whom the work is particularly addressed, the use of mathematics has been kept at a minimum. "As compared with previous editions an innovation has been made, in that diagrams and line drawings have been supplemented by photographs of actual instruments and their parts."

The volume opens with a good discussion of the elementary and theoretical features of the art of measurement, giving particular regard to errors, their causes, compensation and correction. The mechanical design of instruments receives great attention; and the features of operating torques, control and damping, as well as the design and application of permanent magnets and shunts, are thoroughly analyzed.

The types of indicating instruments common to electrical practice in general, and British practice in particular, are covered in great detail, with a particularly valuable treatment of rectifier instruments. While there are outlined a variety of applications of the thermal principle, including a number of practical embodiments of the thermal wattmeter, the use of the thermionic vacuum tube in practical measurement receives little mention. Electrostatic instruments are fully treated, and one chapter is devoted to electrical tachometers. Power factor meters and measurements receive more generous consideration than would be found in a similar book of American origin, and the authors have shown rare courage and sanity in giving a logical, concise and practical discussion of that contentious subject, the power factor of an unbalanced polyphase load. There are also very welcome sections on the measurement of rectified currents and voltages, and on the harmonic voltmeter. In the chapter on Frequency Meters is found a description of Warren frequency control as practiced in England.

Graphic instruments (termed "graphiers") are discussed with a fair degree of completeness, so far as basic principles are concerned. This section of the work must, however, be considered as somewhat "spotty." A novice acquiring his knowledge of graphics from no other source would find his education in this branch of electrical measurement to be one-sided. For a work purporting to present information on "the many forms of electrical measuring instruments now available," this section falls short of its objective. While a relay type of graphic, manufactured by the company with which one of the authors is associated, is described in great detail, a corresponding widely known instrument of American make, appearing in the earlier editions, is here omitted; and the brief incomplete description of another American relay type of movement conceals more than it reveals and is far from being up-to-date.

The relatively new subject of Telemetering, though treated more broadly than that of graphic instruments, shows the same incompleteness and poor perspective. For instance, in describing the thermo-electric method, it is stated that *"It has been proposed* by Fawsett" to perform this measurement; and reference is made to a technical article published eleven years ago. No mention is made of what has been *actually accomplished* on this side of the Atlantic, in transmitting and totalizing measurements of great blocks of power by a similar system. Though the authors describe several methods practically unknown in this country, a number of successful systems which have found wide application in America do not appear.

The recent rapid advances of high-tension distribution in Great Britain have been responsible for special attention being given to the important subject of Instrument Transformers, both for ordinary voltages and extra-high potentials. The characteristics of voltage and current transformers of many forms are admirably covered, and methods of compensation for inherent errors discussed in full.

In the exposition of underlying theories and principles, this book reflects the thoroughness which characterizes British works on measurement; but it is disappointing to find the actual descriptions of instruments dominated by the products of a single manufacturer. While that builder receives frequent mention, the names associated with other makes of instruments are generally those of technicians responsible for particularly interesting features, with no indication of the maker's identity. American practice receives scant consideration, and that of Continental Europe even less; and there is little evidence of effort to bring up-to-date such foreign references as are made.

As a descriptive work, presenting in a systematic manner a maximum of valuable technical material on electrical measurement, with a minimum of resort to abstruse considerations, the book is a masterpiece. For one seeking a general, though perhaps slightly biased, panorama of British measuring practice the volume leaves little to be desired. Though it would seem that the manufacturer's point of view has been permitted to distort the perspective, we must look far to find elsewhere in a single volume an equal amount of concise and authoritative information on the practical measurement of electrical magnitudes.—Perry A. Borden (4)-B-

NEW INSTRUMENTS

Write Information Section, Instruments Publishing Company, for additional information.

"Intermediate" Portable Electrical Instruments

General Electric Co.

IN general, portable instruments for electrical measurements are either (1) large, rather heavy, highly accurate and relatively high-priced, or (2) "pocket-size," light, of rather low sensitivity and accuracy, and relatively low-priced. The new line now announced, Type AP-9, is intermediate in all these respects. It includes voltmeters, milliammeters, ammeters, and wattmeters. The unusually attractive and serviceable case, of Textolite compound with hinged cover and snap lock, measures 2½"x6½"x4¾". With the cover closed, it has no projecting parts; in Type P-8 instruments, now superseded, the binding posts were on the side of the case, but in the new ones

the terminals are under the cover, out of the way and easily connected. The cover also protects the glass over the scale when the instrument is not in use. Flush with the surface there is an external zero adjustment on top of the case. The scale length in mean arc is 4¼". The accuracy is 0.75% of full-scale value, except in the case of the triple-range voltmeters in which it is 1½%, and can be improved by special calibration on the job. Instruments can be read easily to within 0.5% of full-scale value. Instruments other than the 3- and 4-range ammeters, which have an internal transformer, may be used for d.c. as well as a.c. measurements. The voltmeters and ammeters employ the Thomson inclined coil; the wattmeters are electrodynamic. Construction features include knife-edged pointer with mirror scale; highly polished hard steel pivots; sapphire jewels; highest quality tempered phosphor-bronze control springs; magnetic damping with an "overshoot" of 5%; shielding from external magnetic fields; and Permaloy moving vane which is not permanently affected by a magnetic field and which, therefore, maintains its calibration for a long time. When an instrument is used on a d.c. circuit, Permaloy keeps down hysteresis errors and permits the instruments to be used on a.c. circuits again without impairment of accuracy.

Supersensitive Instruments

Westinghouse Elec. & Mfg. Co.

DEVELOPMENTS in supersensitive instruments giving scale deflection of 0-20 microamperes and 0-3 millivolts are the result of reduction in weight of moving parts, a 3 to 1 increase in magnet strength and a 6 to 1 increase in the possible number of turns on the moving coil with relatively slight improvements in many of the elements. Examples of material reductions (permitting lower spring torques and decreasing impact load on pivots and jewels) are illustrated: the coil, slightly

more than ⅝" square, containing 1500 turns of 0.001" diameter wire, is composed entirely of wire and cement. At its ends are shown the newly developed light weight pivots with integral base for cementing to the ends of the coil. On the right are shown the pointer, tail piece and cross arms formed from a single sheet of thin aluminum alloy.

The 3 to 1 increase in magnet strength has been achieved by the use of cobalt steel castings, finished with simple surface grinding operations and spot welded to the soft metal pole pieces in which all mounting holes are then drilled. It is thus possible to make supersensitive instruments having three times the current sensitivity and therefore nine times the watt sensitivity due to use of special magnet steel alone.

The third major improvement applies chiefly to microammeters. The moving coil swings in a fixed air gap, and its dimensions are limited by core on the inside and pole pieces on the outside, so that the only way to increase the number of turns is to use finer wire. Instrument makers had been using No. 44 (0.002") enameled copper wire. Now, the coils are made from 0.001" and .0008" wire, less than half the diameter of the finest human hair.

These instruments are 2" or 2⅞" in body diameter, giving full scale deflection on one or two micro-watts. The lowest standard micro-ammeter has a scale 0-20 micro-amperes, and a coil resistance of about 2100 ohms. Small millivoltmeters are available with scale of 0-3 millivolts with a resistance of about 9.1 ohms. For special requirements, a very highly damped instrument can be obtained by use of the cobalt steel magnet.

◆ ◆ ◆

Küppers Sag Meter

American Askania Corp.

WITH this new instrument it is possible to measure accurately not only the sag of overhead cables, but the height of line supports, the height of wires above ground, the interval between crossing lines, the distance from cables or wire ropes to railroad tracks or other fixed objects, etc. In most cases the instrument can be set up wherever convenient. It is clamped to a tripod head, much as any surveying instrument, and requires no special mathematical knowledge, its design being based on practical applications of the principles of similarity in plane geometry.

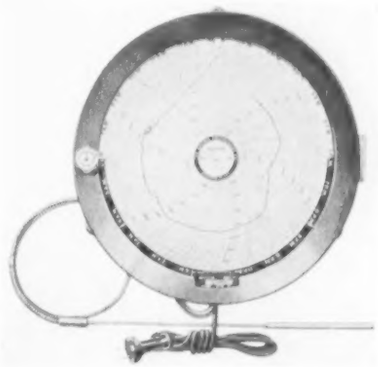
Improved Temperature and Pressure Recorders

Brown Instrument Co.

AN entirely new and improved line of 8" and 12" circular chart instruments includes thermometers in indicating and recording types for temperatures from –40° F. up to 1200° F., and indicating or recording pressure and vacuum gages for ranges from 10" of water up to 5,000 lbs. All types are offered in one, two- or three-pen models.

In developing the new thermometer line, much research was devoted to improving the helix mechanisms (Bourdon tubes). The mercury-filled helix is built of a stainless steel which stands 100% overload and provides a surplus of power to move the pen. The gas and vapor type helices are made of heat-treated phosphor-bronze which gives greatly increased ruggedness and power. Thermometers may be located up to 200 ft. from bulbs.

In the pressure and vacuum gages, three different types of movements are employed: For ranges 10" of water to 30 lbs., a flexible metal diaphragm is



used. For ranges 30 and 200 lbs., a spring-opposed bellows has been developed which gives a powerful pen action in this range. For pressures over 200 lbs., a helix is used.

An electric clock is standard for all models. Where a.c. supply is not available, hand-wound clocks are furnished. Cases are of die cast non-corrosive aluminum and are interchangeable for back or bottom connection or for flush panel mounting. Other new features include:

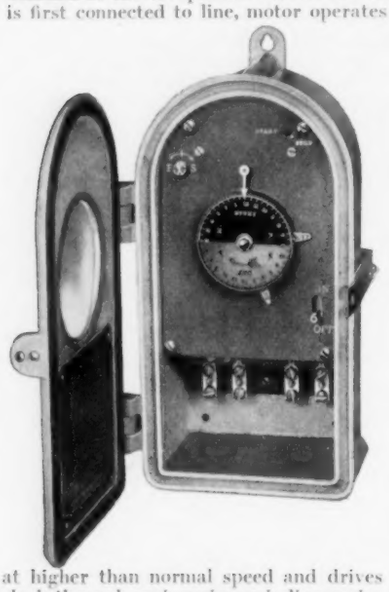
1. Handy toggle switch to start and stop electric clock.
2. Combination door handle and built-in lock.
3. Automatic chart clips carried on door hold chart in place.
4. No chart knob to lose. Chart is simply pressed on chart hub.
5. Automatic pen release lifts pen from chart when door is opened.
6. Greatly increased torque minimizes pen friction effects.
7. Convenient micrometer thumb screw permits easy recalibration, if range of instrument is to be changed after installation.
8. Felt gasket and cemented glass in door make case dust- and moisture-proof.
9. Rugged and accessible zero adjuster.
10. Black Duco enamel finish standard; other colors or types of finishes available.

A great variety of sizes and shapes of bulbs, and a wide choice of standard charts, offered, including unusual ranges for special service in different industries.

Time Switch With Governing Device

Walser Automatic Timer Co.

SEVERAL novel features are said to be found only in the new Utility Model 89, distinguishing it from all other time switches. Drive is direct, from self-starting non-synchronous induction motor, the power of which is controlled through automatic adjustments so as to be "in perfect balance" with the power demand of the escapement. When switch is first connected to line, motor operates



at higher than normal speed and drives clock through mainspring, winding mainspring by reason of excess motor speed. When mainspring reaches pre-determined tension, a change-over device cuts it out and connects motor. Motor speed is then automatically regulated. Should current fail, escapement instantly picks up mainspring. Thus "combining advantages of both motor and spring power," the movement cannot be affected by current failure or by frequency variations, a range of 50 to 65 cycles being permissible. Capacities are 30 amp. at 120 volts; 20 amp. at 220 volts. Switch is single-pole, mercury-to-mercury contact. Housing is aluminum, 9″ high, 5″ wide, 3″ deep. Underwriters' approval has been obtained.

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Automatic Timer

General Electric Co.

BY combinations of two or more of these new timers, or by using one in conjunction with other types of automatic time switches, it is possible to meet a wide range of process schedules. Timing is started by closing a switch. Resetting is automatic when the control circuit is deenergized. When used as a process timer it can be arranged to operate a signal or terminate a process at the end of a predetermined period. By the use of relays and timers together, entirely automatic control can be provided for almost any process.

The Type TSA-10 timer has two scales, graduated in hours or minutes. One of these scales has a range 3 times that of the other. The user chooses the more appropriate scale for the interval he desires to time, by setting the scale-selector lever. He then sets a movable contact at the point on the time scale corresponding to the interval to be timed. The timer is

then set in operation by energizing a "clutch-coil" circuit in the timer by a push button (or by the same switch that initiates the process). The pointer then moves up the time scale and operates contacts when it reaches the point at which they are set. In some applications the timer is arranged to reset itself automatically after operating the contacts; in other applications the timer is reset by opening the "clutch-coil" circuit manually. This is optional, according to how the unit is wired. The timing element is a self-starting Telechron motor. The timers are rated 1 amp. at 115 volts. They are available for 60, 50 or 25 cycles, 115 or 230 volts, contacts normally opened or closed, and with time intervals of 5/15, 10/30, or 20/60 minutes.

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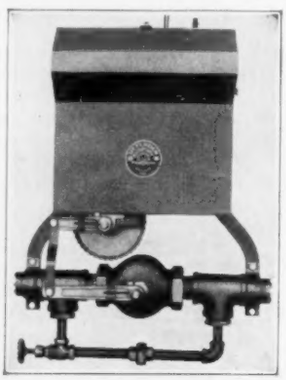
Electric Motor-operated Pressure Controller

Defender Automatic Regulator Co.

ALTHOUGH designated as "Pressure Regulator" because its responsive element is a coiled hollow spring, this new Model B automatic controller may be actuated by vacuum, temperature,



rate of flow, fluid volume, etc., as well as by timing devices. The fact that it comprises a primary system distinguishes it from plain valve-operating devices which do not provide automatic control, and from plain motorized valves which simply "obey" control instruments. The coil spring is adjustable from the outside so that the regulator will work as desired from 20″ vacuum to 250 lbs. pressure. In its mode of operation it is of the adjustable compensating type, the face-plate in front of the final gear (directly connected to valve lever) having 2, 4, 8 or 16 stops, and the compensator itself being capable of causing the regulator to make any number of stops on any change in pressure from 1 to 10 lbs. or more. This is done by supplying light or heavy springs for the compensator. Our illustration shows a Model B pressure controller operating one of the new Defender chronometer valves on a horizontal steam line, with a by-pass to set for minimum speed of fan or stoker engine. The Model B can also be installed on vertical lines.

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Cathode-ray Oscillograph

General Electric Co.

IN this new instrument for the study of recurring waves (from power frequencies to several thousand kc.) a high degree of portability has been attained, and the instrument is readily adapted to switchboard mounting or general classroom demonstration. The complete oscillograph requires only 200 watts, and can be operated from any

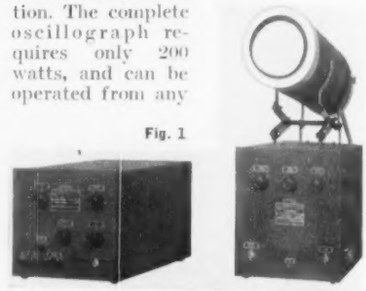

Fig. 1

Fig. 2

110-volt, 50- or 60-cycle source. Full equipment consists (see Fig. 1) of the cathode-ray oscillograph (right) and the time-axis oscillator (left). The cathode tube is fastened adjustably on top of the power-supply housing, within a sheet-iron holder which provides electrostatic as well as magnetic shielding. Within the power supply housing are mounted the necessary filament transformers, a high-voltage transformer, and the rectifier tube and capacitors for operation of the cathode tube at 3000 volts. This unit is a complete cathode-ray oscillograph, with a high beam-voltage, a sharp clear spot on the fluorescent screen, and two sets of deflecting plates at right angles to each other for deflection voltages. Measurements of voltage and current amplitude and reentrant patterns, known as cyclograms or Lissajous' figures, can be obtained with this unit. These are valuable for studies of relative wave shapes and phase relations, as in frequency powerfactor, and corona-loss measurements.

Standing wave images are produced by means of the time-axis oscillator unit (left, Fig. 1) in which suitable circuit adjustments are provided to give a range of time-axis oscillation from 30 to 20,000 cycles, and by means of a special interlocking connection the time-axis frequency and the unknown wave frequency are held at a fixed ratio.

The G-E Type FP-53 cathode-ray tube (Fig. 2) used in this oscillograph, is of

the hot-cathode type, highly evacuated and permanently sealed. On the average, it operates successfully for 1000 hours. As it is operated at a cathode-beam voltage of 3000, a very brilliant image is produced on a large screen. Demonstrations can therefore be made before large audiences without darkening the room, and photographs of the image can be made with standard cameras. The deflection sensitivity of this tube operating at 3000 volts is as follows:

Front plates (nearest viewing screen) Approx. 150 volts per in.
Back plates Approx. 75 volts per in.

On the panel of Unit No. 1 are mounted 3 controls for the adjustment of the cathode spot; also 2 toggle switches, one in the filament transformer circuits, and the other in the high-voltage transformer excitation circuit. On Unit No. 2 are located controls for regulating the frequency of the timing wave and a toggle switch to open and close the 60-cycle power supply. Other data:

Unit	No. 1	No. 2
Panel width, in.	11.5	11.5
Panel height, in.	12.2	10.5
Box length, in.	19.5	19.5
Weights, lbs.	55	42
Power consumption, watts.	150	50

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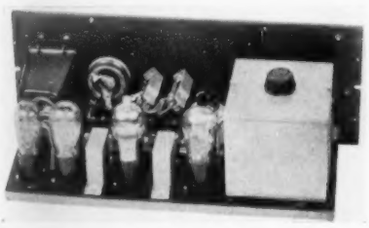
New Frequency Equipment

Int'l Broadcasting Equipment Co.

TYPE 50 FREQUENCY CONVERTER

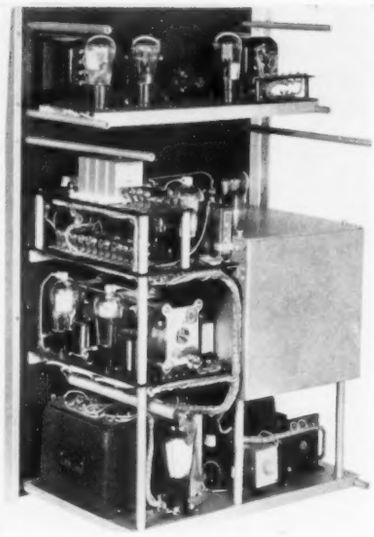
ON all approved frequency monitors except that described below, there is no means for checking against a standard of frequency without acquiring considerable apparatus, it is said. With this in mind, the Type 50 frequency converter has been brought out, whereby any transmitter and its monitor can be set accurately to frequency and checked at intervals. It permits the accurate setting of other crystal control equipment, whatever the frequency upon which the device to be



checked may be operating, provided such instrument is operating on a frequency approx. a multiple of 10 kc. It employs a circuit similar to that of the Type 60 frequency monitor described below: a crystal controlled 100-kc. oscillator circuit is followed by a buffer amplifier which excites a multivibrator circuit operating at 10 kc. The crystal and holder assembly is mounted in a metal box lined with 1" of balsa wood. Adjustment of crystal frequency is made by an insulated shaft driving the upper plate of the holder which revolves on a micrometer thread; fine frequency adjustment is made by means of dial on panel front. Rapid compensation for drift is an outstanding feature.

TYPE 60 FREQUENCY MONITOR AND TYPE 100 FREQUENCY METER

SAID to be the result of a long period of intensive research, this new universal frequency monitor possesses features which were developed by giving consideration to "the usefulness of this instrument in the future."



It is entirely a.c. operated except for the "C" batteries needed for the beat indicator and the frequency meter. Complete installation (no special coupling coils needed) may be made in a few minutes by the average station engineer. Plate and filament voltmeters are provided. Frequency adherence is to ±5 parts in a million; maximum frequency error is the drift over one week (between Tuesday checks against Bureau of Standards' WWV) and this maximum drift should be almost negligible by reason of provisions for correcting it. The monitor is "universal" in that it may be used on almost any band of frequencies by the addition of plug-in coils. There are 2 visual indicators: a beat indicator and the Type 100 Frequency Meter. This is essentially a vacuum tube device with a scale calibrated up to 100 cycles, the scale interval for a 10 cycle variation being approx. ½". Other ranges can be supplied.

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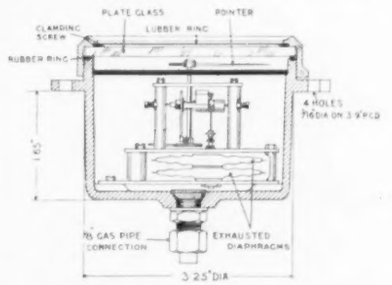
Absolute Pressure Gage

Negretti & Zambra

DESIGNED in particular for indicating the true or absolute pressure in the intake of aircraft engines equipped with superchargers, this new "Boost Gauge" has a movement, contained in an air-tight case, consisting

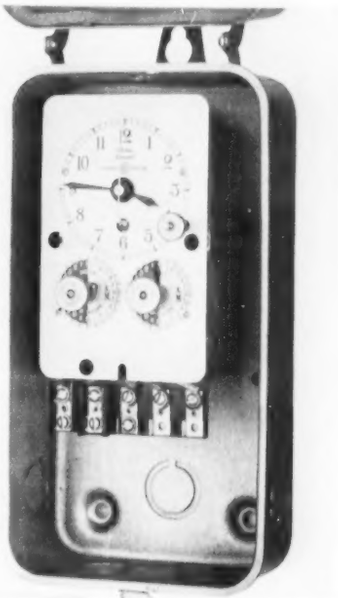


of 2 exhausted capsules operating a pointer through a sector-and-pinion mechanism similar to that of an aneroid barometer. The range is −4 to +4 lbs./in.² with −12 to +8 lbs./in.² overload. The accuracy certificate specifies the maximum errors, in various portions of the scale, due to various temperatures and to various positions.

New Electric Timers

General Electric Co.

INCLUDED in the new Type T-14 time switch line are the following: (1) A utility switch (illustrated) which turns on and turns off once every 24 hours. Finished in glossy black, with clock face and setting dials below, it ornaments a counter, and can be connected to an adjacent display sign. It will turn radio sets on and off, and in a house it may also deter burglary by turning on a lamp to give apparent evidence of occu-



pancy on evenings when the family is away. (2) An electric-range timer is in a similar attractive case, but the mechanism is so arranged that the on-off cycle is not repeated automatically. It is used to turn the oven of an electric range on and off automatically; it can also control one burner of the cooking top if the range is provided with the necessary connections. (3) A hanger-mounted thermostat timer is for use with double-range (day and night) thermostats commonly employed in the control of house-heating systems. It has an "a.m. and p.m." indicator, and a dial for setting the clock at a.m. or p.m. time. Two other pointers are used to set the mechanism to the proper time setting for the day and night temperature regulators to be put in operation.

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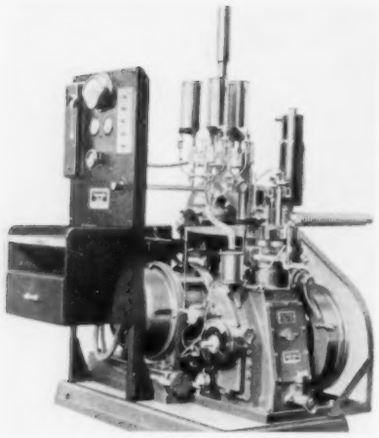
Motor Method for Gasoline Knock Characteristics

OF importance to the automotive and petroleum industries is the adoption by the American Society for Testing Materials of the "CFR Motor Method" for determining the octane numbers of gasolines and equivalent fuels used in spark ignition engines other than engines for aircraft. This method is based on the apparatus and procedure developed by the Cooperative Fuel Research Committee composed of representatives of the American Petroleum Institute, National Automobile Chamber of Commerce, Society of Automotive Engineers, and the U. S. Bureau of Standards. A standardized engine is the basic instrument. Its present form was adopted



as the result of tests both with vehicles on the road and in the laboratories of many petroleum refineries and of the Waukesha Motor Co. The equipment consists of a variable compression, single cylinder, overhead valve engine 3¼" bore by 4½" stroke equipped with a special type carburetor, electrically heated intake manifold, steam cooling, electric heat control for lubricating oil, and having a movable cylinder which can be raised or lowered while the engine is in operation to secure compression ratios ranging between 3:1 and 30:1 without change in valve adjustments. Engine, auxiliaries, and indicators are mounted on a common bedplate with a special synchronous induction motor which serves as a starting device, and also a loading device for the engine. Perfect control of the speed, temperature, ignition advance, and all other factors becomes automatic. Suitable bouncing pin indicators with gas evolution burette or electric indicating knockmeter are all mounted with the control switches on a switchboard panel.

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Reclosing Device for Oil Circuit Breakers

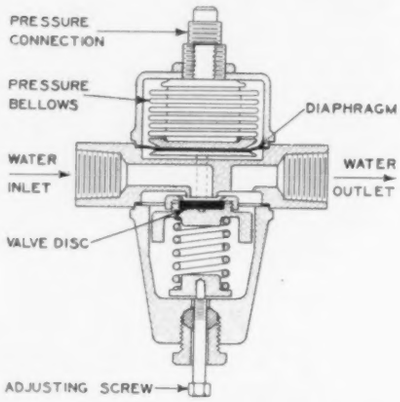
General Electric Co.

FOR use with oil circuit breakers, the new Type SM mercury-tube attachment will reclose a breaker 1, 2 or 3 consecutive times, with equal time intervals between reclosures, when the breaker is tripped by overload. If the overload disappears after any reclosure, the attachment returns to its normal position and the breaker remains closed. If the overload still exists after the last reclosure, the breaker remains locked open and must be closed manually before any further automatic operation takes place. Timing is obtained by running mercury through an orifice into a reclosing contact chamber. The number of consecutive reclosures, and the time interval between reclosures, are fixed during manufacture. A new tube, however, can be readily substituted if a different number of reclosures or some other time interval is desired. The attachment is directly connected to the breaker mechanism and is available with both solenoid and motor-operated breakers. It can be furnished with outdoor breakers and switch house equipments, also for use with indoor breakers which have various mountings such as pipe or angle iron framework and metal-enclosed.

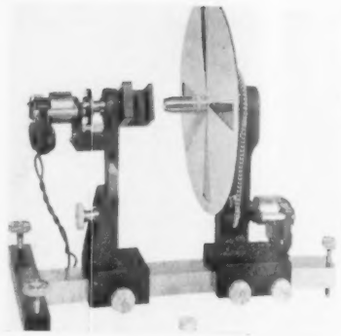
Water Circulating Valve

C. J. Tagliabue Mfg. Co.

MEETING latest requirements of refrigeration engineers, this new valve mechanism proportions the valve opening to the refrigerator cooling system's demand for water. The low-pressure model moves from tight shut to wide open through an increase of 15 to 20 lbs. in refrigerant pressure; the high-



pressure model, through approximately 30 lbs. Bronze bellows withstand, respectively, 150 and 200 lbs./in.² without rupturing, and are protected from water by rubber diaphragms. The valves will close off or throttle against water pressures up to 80 lbs./in.² and a convenient adjusting screw permits quick change of setting point. Inlet and outlet are ⅜" s.p. and characteristics approximate those of a ⅜" single-seat hand valve.



Precision Back-Reflecting X-Ray Camera

American Instrument Co.

THE instrument illustrated is for the study of the composition of metals and other crystalline substances by the X-ray diffraction method. A pencil of rays passes through a hole in the center of the disc that carries the film, impinges on the specimen, and is broken up and reflected back onto the film. Each homogeneous substance so treated gives a characteristic series of rings on the film, so that the constituents of a complex or alloy specimen may be identified from the ring-pattern produced. A feature of the instrument illustrated is that both specimen and film disk are rotated as the picture is being made. The effect is as though the number of exposed crystals in the specimen face were greatly increased, and in the resulting picture the rings are much sharper and easier to identify than in the stationary type.

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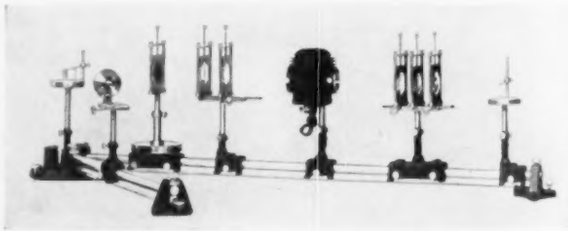
Universal Optical Bench

R. Fuess, Inc.

HUNDREDS of different set-ups are possible by variously arranging the several principal parts and the many auxiliary attachments of this ingenious new outfit which is of American design and manufacture. A rough idea of its flexibility may be had by examining Fig. 1 which shows (left to right) a fixed-angle base, a slide table, a single lens holder (on a revolving-unit rider), a duplex lens holder, a lamp house, a triplex lens holder and a turn-table, as well as 2 supporting bases. The bench proper is constructed of two ¾" chromium-plated steel rods which come in standard lengths of 500, 1000 and 2000 mm., so that overall bench length can be increased by inserting a longer bar, whereas in present type precision benches a length of 2 m., for example, would be costly. The variable angle base, Fig. 2 (not shown in Fig. 1), is said to open up new fields of optical-bench experiments, including as it does a 5" disk with 2 verniers permitting readings to <5' and a standard post which can accommodate any of the platforms or other holding devices in the new Fuess line. The manufacturer's announcement states that "such attachments or devices as you may already possess" may in like manner be fitted for use with this universal bench.



Hair Hygrometer

S. M. Schreiber

HUMAN hair is the sensitive element of this newly introduced American-made hygrometer. Its 3" dial is graduated from 0 to 100% relative humidity with the range 40 to 60% accentuated. Clock-like in form and low in price, it is intended for the home, office or shop rather than for the laboratory.

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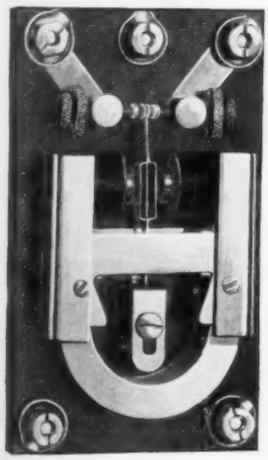
Polarized Relay

Struthers Dunn, Inc.

DESIGNED for operation where the d.c. in the operating coils must be kept as low as possible, and where a reversal of the current in the operating coils brings about a reversal in the contact arrangement, but where no contact is made when the coils are deenergized, the new Type PM 101 relay consists of a permanent magnet and two coils ar-



ranged to give a push-pull effect on the armature carrying the moving contacts. The strength of the permanent magnet is adjustable by a movable shunt. The position and tension on the moving contact member are adjustable, and the fixed contacts are also adjustable. The insulating base measures 5"x3"x½". Overall depth is 2½", including base. Contacts are rated to carry and break 2 amp. at 110 volts, a.c., or ¼ amp. at 115 volts, d.c., non-inductive load. Relays can be furnished with total coil resistance up to approx. 6,000 ohms, and satisfactory operation can be secured with a power consumption as low as 1/100 watt, d.c.

The Metric Gravitometer

American Meter Co.

EFFECTS of variations in atmospheric pressure and temperature are automatically eliminated in this new instrument, so that the continuous record of gas specific gravity on its chart is correct. A blower, Fig. 1, is the fundamental element of this instrument. A continuous sample of gas at 10 lb. pressure enters through connection E, passes through pressure regulating valve F into

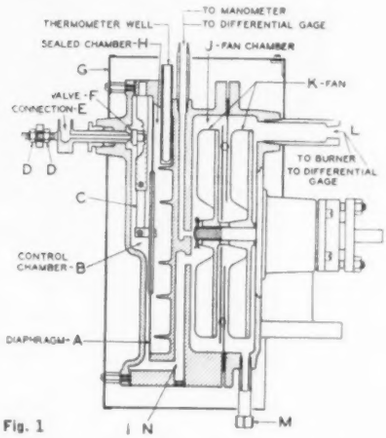


Fig. 1

control chamber B, then through tube N into the center of the fan chamber J and finally to an adjustable burner (attached to tube L) where the gas is burned.

Between control chamber B and fan chamber J is a sealed chamber H in which a definite quantity of air is enclosed, at 30" mercury abs. and 60° F. The pressure within the sealed chamber varies with the abs. temperature of the contained air, but its density, or weight per cu. ft., remains a constant. These 3 chambers are enclosed within an asbestos lined jacket so that gas temperature within all 3 is the same. Between sealed chamber H and control chamber B is flexible metal diaphragm A. Connected with it is lever C which operates valve F for maintaining gas pressure in chamber B always equal to air pressure within the sealed chamber. Thus, the effect of pressure and temperature on the density of the gas is maintained constant, as the density of the air within the sealed chamber is constant, since the diaphragm is always maintained in its neutral position. When gas is admitted to the control chamber, any change in its density is due only to a change in its specific gravity.

The differential pressure produced by a centrifugal fan running at constant

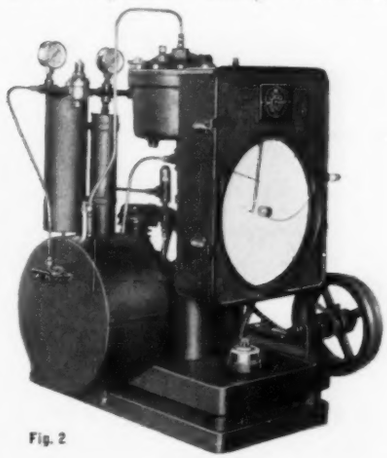


Fig. 2

speed within a gas varies as the density of the gas. Since effects on density due to changes of temperature and pressure are automatically eliminated, the differential pressure produced by the blower K varies only with a change in specific gravity. If the differential produced by the blower when rotating in air is 1.0 as indicated on the chart, the differential produced by the blower when rotating in gas will be the specific gravity of the gas.

The above assumes that the speed of the blower is constant. This is assured by the synchronous motor. The current supply, therefore, should be constant-frequency 60-cycle a.c. The Metric Gravitometer should be mounted on a solid base free from vibration, located where the temperature will not be less than 50° F. Temperatures up to 120° will not affect the operation.

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The Resistometer

Thwing Instrument Co.

SPECIALLY constructed for checking electrical resistance thermometers and their bulbs, this new instrument is designed to be used both for the fine measurements in laboratories and as a portable checking and calibrating set for everyday plant use. It combines in a compact unit a Wheatstone bridge, with a stepped resistance for measuring all resistance to 1000 ohms, a resistance bulb comparator and the Resistocrit, a special resistance circuit for checking all types of resistance thermometers, whether direct deflection type or null method type.

No technical knowledge is required to operate the instrument, which has the capacity to measure 1000 ohms. There are 3 stepped or decade scales. The slide wire scale, capacity 11 ohms, is easily readable to 0.01 ohm for close accurate readings. Dial R2 is arranged to measure 90 ohms in steps of 10 ohms and dial R1 is arranged to measure 900 ohms in steps of 100 ohms.

The Resistance Bulb Comparator consists of two sets of three binding posts and a double throw switch, to check the accuracy of electrical resistance thermometer bulbs against a standard bulb of known accuracy kept for this purpose.

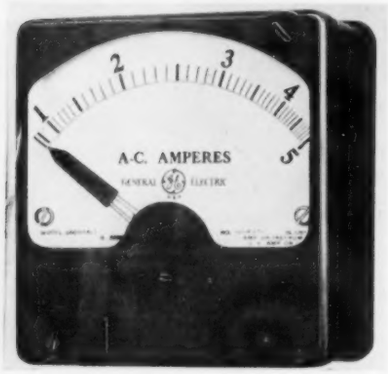
The Resistocrit is a resistance circuit which can be adjusted to read any values on the same stepped scales used for the Wheatstone bridge. Three binding posts at the upper right of the panel are used to make the connections to this circuit, which permits checking any kind of resistance thermometers without the use of a resistance bulb. The Resistocrit takes the place of and performs the function of a highly accurate standard bulb.

The Resistometer is contained in a solid walnut case. The cover is mounted on sliding hinges so that it may easily be removed and replaced.

Rectangular Switchboard Instruments

General Electric Co.

AMONG advantages of a new line of rectangular switchboard instruments is that the scale can be read at an angle with no error of parallax. Antiglare glass is another special feature. Others are magnetic damping, high torque, responsiveness, permanently constant characteristics, and availability in 3 styles of cases. The line, designated as Types AD-6 and DD-6, includes a.c. voltmeters, ammeters, wattmeters, power-factor meters and frequency meters, and d.c. ammeters and voltmeters; also temperature indicators and radio-frequency and rectifier-type instruments



—all in surface or flush type cases. The surface type instruments are 6″ high and 5½″ wide, and 4 instruments may be mounted on a 24″ panel; flush type 7″ high and 6½″ wide. In addition, 3-element ammeters and voltmeters, 12″ high and 5½″ wide, are available. Principal applications: switchboard builders, central stations, power plants, manufacturing plants, railroads, etc.

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"Radif" Thermometer

Dry-Zero Corp.

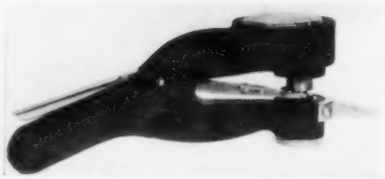
DEVELOPED by Harvey Lindsay, president of Dry-Zero Corp., a new thermometer indicates directly "effective temperatures" under the sun's rays or in the path of other radiant heat. An ordinary thermometer exposed to solar radiation on a summer day would perhaps read 132° F. whereas Lindsay's thermometer would read 226° F. The "Radif" thermometer, in its simplest form, consists of a chemical black bulb thermometer arranged to permit absorption of radiant heat. Except for a small aperture, the bulb is surrounded by insulation to eliminate re-radiation and conduction, allowing the bulb temperature to build up to the practical equivalent of the total heat impact. Principal applications, railroad passenger car air conditioning, refrigerator car design, refrigerated truck specifications (particularly roof and floor insulation), and specifying composition roofings, asphalts, paints and insulation.

◆ ◆ ◆

Thickness Gage

Federal Products Corp.

CLAMPING the material being gaged, before the measuring anvils come in contact with it, eliminates dependence on human touch when using



this new instrument. There are two aligning surfaces, ¾″ in diameter. The stationary gaging point is in the center of the lower one; in the upper one is the point making direct contact with the dial indicator. To use, insert work between anvils and release handle lever: the work is then securely clamped and the thickness indicated on the dial. The projecting shoe at the right on the illustration is simply a guide to facilitate inserting the work between the anvils. The dial indicator has two tolerance hands which can be set for any desired limits, speeding up inspection work.

◆ ◆ ◆

Snap Action Temperature and Pressure Controllers

C. J. Tagliabue Mfg. Co.

DESIGNED for domestic refrigerators and similar applications, these new controllers are compactly housed in small Bakelite cases, with either a toggle switch and octagonal range-adjustment knob (as in illustration), or push-pull switch and round range-adjustment knob, on the name

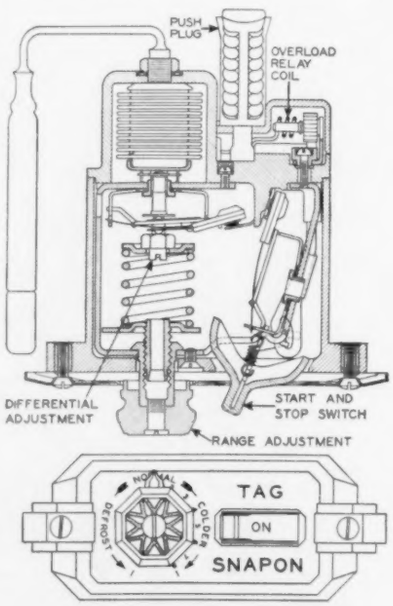
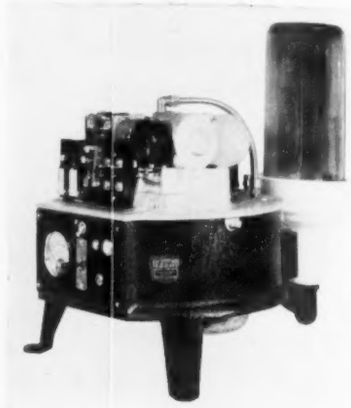


plate. At the back of the case is a push plug to facilitate making connections and prevent loose connections due to vibrations. Specially designed contacts have been approved by Underwriters Laboratories for use with 1/3 h.p. a.c. motors at 110-220 volts and ¼ h.p. d.c. motors at 115-230 volts without relay. Standard overload relay coils are easily accessible. Semi-automatic defrosting, said to be a unique feature, allows evaporator coils to defrost while maintaining safely low food compartment temperature.

Photoelectric Meter-Alarm for Water Hardness

Elgin Softener Corp.

AUTOMATICALLY testing the hardness of water, the new Elgin Hardimeter also sounds an alarm when the hardness exceeds any predetermined figure. The instrument, for use on water produced by a Zeolite water softener, is also used to check the brine wash water so that the softener will not be placed in service until all the brine has been removed. It is connected to the soft water supply line by copper tubing, and at predetermined intervals (2 to 20 minutes) a sample of the water automatically passes into a glass cylinder. A



small quantity of chemical is mixed with the water sample. The slightest trace of hardness causes both a turbidity and a change in color, such change being in proportion to the amount of hardness. After time for reaction of the chemical with the sample, a beam of light is passed through the glass cylinder to a photocell, the output of which varies with the transparency of the sample. The hardness is thus determined by readings on a meter scale. Whenever the hardness is found to be greater than that for which the instrument has been set, an alarm is given by ringing a bell, flashing a light, or both. The audible or visible signal is continuous until a reset key is operated.

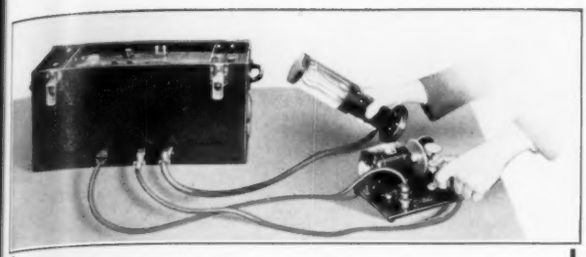
The entire cycle is automatically accomplished. The inside of the glass cylinder is mechanically wiped just prior to each test. The Hardimeter is offered in two models. One is designed for use where the water is practically uniform. The other is for use where water to be tested varies appreciably in either color or turbidity.

◆ ◆ ◆

Portable Platform Scale

The Kron Co.

THIS scale is built with a 21″x29″ platform so designed that the platform plate does not overhang the suspension loops. This permits extreme loads to be placed on edges of platform without disturbing accuracy. An important feature is that the levers have no lateral movement. Regular construction is with 4 wheels made of a combination of Bakelite and rubber. If desired, 3-wheel construction can be furnished and the scale fitted with a handle for easy movement about the plant.



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New Principles in Precision Regulators

(Continued from page 170)

In the rare event that the excessive pressure arises because of a leak through the valve of the first stage, as for instance as a result of gross carelessness in repairing or assembling the regulator, the relief valve will directly vent the first stage cavity. Whatever the cause of the operation of the relief valve, its operation will always be accompanied or preceded by the display of a red bordered signal button in the back cap of the regulator, which will be forced outward under the influence of the first stage diaphragm in event of any pressure appreciably higher than normal. In this manner a visible signal is given whenever any abnormal pressure has developed. The signal remains displayed until it has been restored by hand. It indicates that at the first reasonable oportunity the regulator should be removed from service for inspection and possibly for repairs. The relief valve functions at a pressure of approximately 175 lbs./in.^{2} and reseats itself after the trouble has been cleared. All pressure-containing parts are made from sound brass forgings, and pressure tests have shown that the regulator is capable of withstanding pressures many times the pressure which is sufficient to cause the relief valve to operate.

(8) Regulator Flow Meter—As illustrated by Fig. 10, a special flow meter of the "variable area" type has been designed for this regulator. The graduated tube, constructed of a transparent synthetic plastic, contains two parallel gas passages. The central passage, which contains the stainless steel float-ball, is conoidal, diverging up. Through it the gas passes up, raising the float ball to a height proportional to the rate of flow. The gas then passes down through a small rear passage and thence out through the regulator outlet. The flow meter illustrated is graduated in liters per minute of dry oxygen flowing at a temperature of 70°F. and referred to a temperature base of 70°F. and to a pressure base of one atmosphere. The graduations range from 0.5 to 15 liters per minute. The meter readings are in general precise to within 2%.

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The regulator without the flow meter has been designed for a maximum rate of discharge on the order of 200 cu. ft. per hour (approximately 100 liters per minute) of oxygen or any gas of approximately the same specific gravity. For a gas as light as hydrogen the capacity is about four times as great. For carbon dioxide the capacity should not normally be regarded as over 15 cu. ft. per hour if the drain upon the regulator and hence the severe precooling effects of carbon dioxide are very great. (For greater outflows, it is well to pass the carbon dioxide through a heating coil immersed in a hot water bath before it reaches the regulator.) This device, through slight alterations in design, has proved useful in regulating gas delivered from oxygen, nitrogen, hydrogen, acetylene and carbon-dioxide cylinders. All other gases which do not attack the regulator parts may conceivably be regulated with this device. Of course, it must be fitted with proper inlet and outlet connection threads and it must not be indiscriminately used first for a fuel or oil-rich gas and then for oxygen. In other words, the usual safety precautions must be observed.

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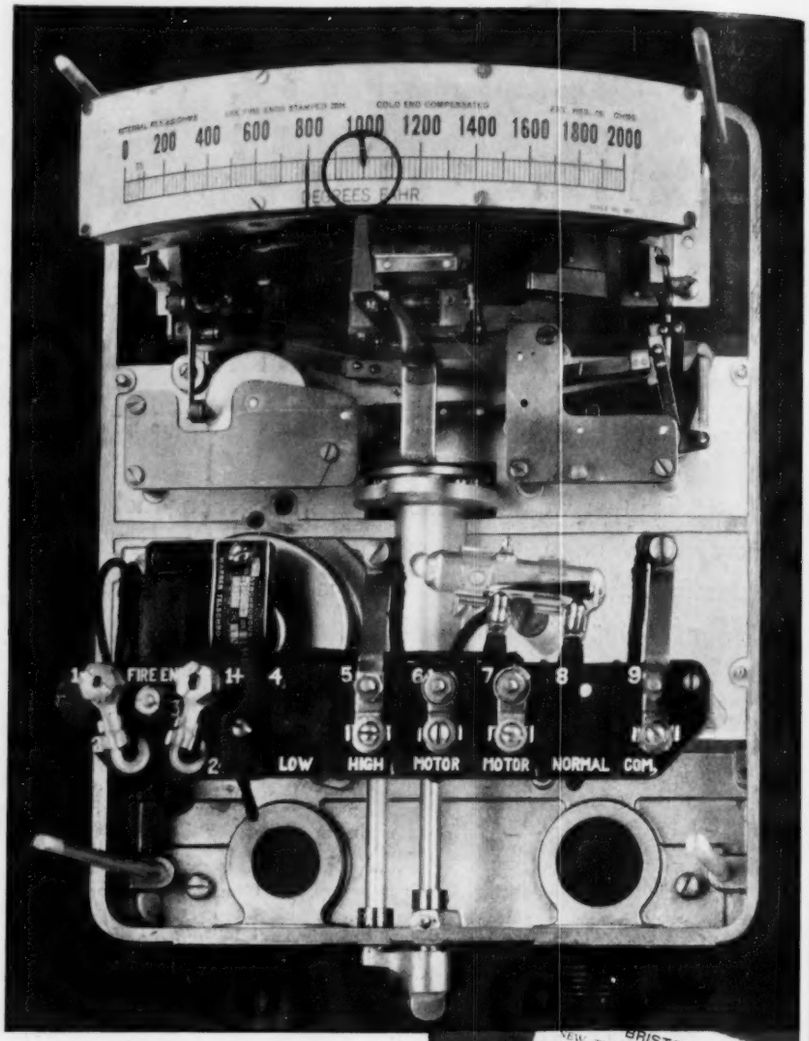

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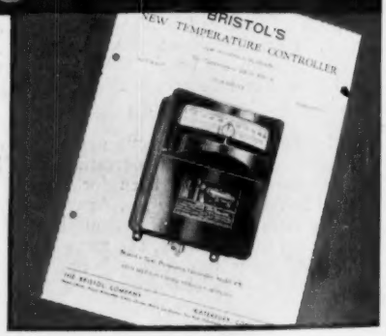

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